

**DISTRIBUTION A:**

Approved for public release; distribution is unlimited.

School of Advanced Airpower Studies  
Maxwell AFB, AL 36112

# Form SF298 Citation Data

<b>Report Date</b> ("DD MON YYYY") 00061999	<b>Report Type</b> N/A	<b>Dates Covered (from... to)</b> ("DD MON YYYY")
<b>Title and Subtitle</b> Paradigm Lost Rethinking Theater Airlift to Support the Army After Next		<b>Contract or Grant Number</b>
		<b>Program Element Number</b>
<b>Authors</b> Allvin, David W.		<b>Project Number</b>
		<b>Task Number</b>
		<b>Work Unit Number</b>
<b>Performing Organization Name(s) and Address(es)</b> School of Advanced Airpower Studies Air University Maxwell AFB, AL 36112		<b>Performing Organization Number(s)</b>
<b>Sponsoring/Monitoring Agency Name(s) and Address(es)</b>		<b>Monitoring Agency Acronym</b>
		<b>Monitoring Agency Report Number(s)</b>
<b>Distribution/Availability Statement</b> Approved for public release, distribution unlimited		
<b>Supplementary Notes</b>		
<b>Abstract</b>		
<b>Subject Terms</b>		
<b>Document Classification</b> unclassified		<b>Classification of SF298</b> unclassified
<b>Classification of Abstract</b> unclassified		<b>Limitation of Abstract</b> unlimited
<b>Number of Pages</b> 118		

PARADIGM LOST

RETHINKING THEATER AIRLIFT  
TO SUPPORT THE ARMY AFTER NEXT

BY

MAJOR DAVID W. ALLVIN

A THESIS PRESENTED TO THE FACULTY OF THE SCHOOL OF ADVANCED  
AIRPOWER STUDIES FOR COMPLETION OF GRADUATION  
REQUIREMENTS

SCHOOL OF ADVANCED AIRPOWER STUDIES

AIR UNIVERSITY

MAXWELL AIR FORCE BASE, ALABAMA

JUNE 1999

## **Disclaimer**

The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University. In accordance with Air Force Instruction 51-303, it is not copyrighted, but is the property of the United States government.

## *Contents*

	<i>Page</i>
DISCLAIMER .....	ii
LIST OF ILLUSTRATIONS .....	vi
LIST OF TABLES .....	vii
ABOUT THE AUTHOR.....	viii
ACKNOWLEDGMENTS.....	ix
ABSTRACT .....	x
INTRODUCTION.....	1
Assumptions and Limitations .....	3
THE ARMY AFTER NEXT CONCEPT.....	6
Genesis .....	6
Scope .....	8
Geostrategic Environment .....	8
Human and Organizational Issues .....	9
Evolution of Military Art.....	10
Technology Trends .....	11
Force Structure – The Hybrid Force .....	17
Concept of Operations .....	20
Project the Force .....	20
Protect the Force .....	21
Gain Information Dominance .....	22
Shape the Environment; Set Conditions for Success .....	22
Conduct Decisive Operations .....	22
Sustain the Force.....	25
Conclusions.....	26
ARMY AFTER NEXT IMPLICATIONS FOR THEATER AIRLIFT .....	28
Austere Operations.....	30
Super Short Takeoff and Landing (SSTOL) .....	31
Opportune Landing Sites .....	34
Cargo Handling Capability .....	35
Situational Awareness.....	37

Defensive Systems .....	39
Operation Thursday – Burma, 1944.....	41
CURRENT THEATER AIRLIFT CAPABILITIES .....	47
C-130E/H .....	49
Austere Operations.....	50
Cargo Handling Capability .....	51
Situational Awareness.....	51
Defensive Systems .....	52
Growth Potential .....	52
C-130J (and J-30).....	53
Austere Operations.....	54
Cargo Handling Capability .....	55
Situational Awareness.....	55
Defensive Systems .....	56
C-17.....	56
Austere Operations.....	56
Cargo Handling Capability .....	57
Situational Awareness.....	58
Defensive Systems .....	58
CH-47D.....	59
Austere Operations.....	59
Cargo Handling Capability .....	59
Situational Awareness.....	60
Defensive Systems .....	60
V-22 .....	61
Austere Operations.....	61
Cargo Handling Capability .....	61
Situational Awareness.....	62
Defensive Systems .....	62
Coming Up Short .....	62
BRIDGING THE GAP – FUTURE THEATER AIRLIFT CONCEPTS .....	67
Austere Operations.....	67
Opportune Landing Sites .....	70
Precision Airdrop .....	72
Cargo Handling Capability .....	74
Situational Awareness.....	79
Defensive Systems .....	81
It All Sounds Good .....	83
ANALYSIS AND CONCLUSIONS .....	85
Austere Operations.....	86
Cargo Handling Capability .....	87
Situational Awareness.....	90
Defensive Systems .....	91
Other Key Considerations.....	94

Conclusions.....	97
BIBLIOGRAPHY .....	101

## ***Illustrations***

	<i>Page</i>
Figure 1. Decisive Operations Across the Battlespace .....	23
Figure 2. Offloading the “Prime Mover” from a C-47.....	44
Figure 3. Boeing Tilt Wing Advanced Theater Transport .....	68
Figure 4. Lockheed Advanced Theater Transport.....	70
Figure 5. Robotic Transport System (RTS) .....	75
Figure 6. Loading with Double-Hinged Cargo Ramp.....	76
Figure 7. Automated Manipulator Arm.....	77
Figure 8. Load-By-Wire Articulated Ramp .....	79
Figure 9. Layered Survivability .....	81
Figure 10. Mobil e Offshore Base.....	97

## ***Tables***

	<i>Page</i>
Table 1. Current Theater Airlift Platform Capabilities .....	48

## ***ABOUT THE AUTHOR***

Major David W. Allvin was commissioned through the United States Air Force Academy in 1986. Graduating from Undergraduate Pilot Training in 1987, he went to fly C-12s at Ramstein Air Base, Germany, departing in 1990 as a flight examiner. He was then stationed at McChord AFB, Washington as a C-141 aircraft commander, instructor pilot and flight examiner. In 1993, he was selected for the USAF Test Pilot School at Edwards AFB, graduating in 1994. Among his primary test programs were the C-17A and C-130J platforms. Major Allvin has accumulated more than 4,000 hours in over thirty aircraft types. He has a bachelor's degree in Astronautical Engineering from the USAF Academy, and a master's degree in Business Management from Troy State University. In July 1998, Major Allvin entered the School of Advanced Airpower Studies at Maxwell AFB, Al.

### *Acknowledgments*

I would like to express gratitude to Dr. Dave Mets for his assistance and mentorship throughout this project. Thanks also go out to Dr. Hal Winton for assistance in focus and structure. Mr. Mike Rohrlick from the Boeing Company and Mr. John Nichols from the Lockheed Company were also very gracious in sharing their time and ideas on this subject.

## *Abstract*

This study analyzes the theater airlift implications for the United States Army's new vision for land warfare in the 21<sup>st</sup> century, the Army After Next (AAN). The AAN planners envision a lighter, leaner, and more lethal force that will rely heavily on information dominance to maximize combat effectiveness throughout the projected nonlinear battlespace. This new vision requires a change in the role of theater airlift. This thesis addresses the question, "What theater airlift capabilities will be critical to support the Army After Next, and which emerging systems provide the best path to achieve such capabilities?" This paper provides a brief explanation of the fundamental elements of the AAN concept, and their implications for future airlift. From that analysis, the thesis identifies four key capabilities that will be required of theater airlift at unprecedented levels: 1) austere operations, 2) cargo handling capability, 3) situational awareness, and 4) defensive systems. After describing current theater airlift capabilities, the paper provides some alternative paths to acquire the necessary airlift capabilities. The following conclusions were among those developed through analysis. Based on the data available, the tilt wing concept provides the best platform to meet AAN lift/airfield requirements. Also, austere operations will require a "stand-off" capability for evaluating the suitability of opportune landing sites. Autonomous, efficient cargo handling systems embedded in the design of the aircraft will not only enhance flexibility but also increase survivability in hostile environments.

# Chapter 1

## Introduction

*“Si vis pacem, para bellum” (If you want peace, prepare for war)*

Roman Proverb

Since the end of the cold war, rapid and sweeping changes in the strategic environment have forced the U.S. Army to evaluate new ways to support the National Military Strategy. The single great threat against which the force has organized, trained, and equipped no longer exists. Amorphous, unpredictable threats have emerged in its place. Cold war catch phrases such as “the Red Bear,” “nuclear winter,” and “the evil empire” have been replaced by “asymmetric operations,” “transnational threats,” “soft security issues,” and “cyberwar.” These terms represent threats that are not easy to visualize and are therefore also difficult to demonize. The military has been fighting an uphill battle to justify funding a defense force to deal with such threats. The defense budget for FY 1998 was 3.2% of the GDP, the lowest point since before World War II.<sup>1</sup>

In an effort to support the United States’ engagement policy for the 21<sup>st</sup> century under austere budgets, the Army has embraced the Army After Next (AAN) concept. This concept is the follow-on to the Force XXI notion, which is a transformation of the

---

<sup>1</sup> U.S. Bureau of the Census, *Statistical Abstract of the United States, 1998* (Washington D.C.: Government Printing Office, 1998), 358. Also, U.S. Bureau of the Census, *Statistical Abstract of the United States, 1980*, (Washington D.C.: Government Printing Office, 1981), 366.

current pared-down cold war structure to a lighter, leaner force. The cornerstone of the Army After Next is the ability to exploit technological advances to accomplish the mission with fewer forces across the spectrum of conflict. Accompanying this change in force structure will be an emergence of supporting concepts to include logistics and sustainment requirements. As forward basing dwindles and the force becomes increasingly CONUS-based, the role of the Air Force mobility forces will become more critical.

Currently, all of the Air Force mobility assets are designed around the cold war concept of operations. Though the C-17 is still relatively “bright and shiny” (as of 1 Jan 99 less than 30% of the initial approved fleet had been fielded), Congress approved it for initial developmental test and evaluation in 1981 when the cold war was still in full swing.<sup>2</sup> The C-130J is the newest airlifter, but it represents a technological facelift on an airframe design that is over forty years old.

In large part, the operational concepts of Air Force airlift must evolve in concert with those of the Army. These new operational concepts will drive weapons systems procurements. Although the Army After Next vision is planning for a force that will not be fielded for another twenty-five years, procurement planning must be considered now. In the past two decades, the average lifetime of a weapons procurement program from initial testing to fielding was fifteen years.<sup>3</sup> Investigating air mobility concepts to complement the AAN now will enable the Air Force to integrate them smoothly with

---

<sup>2</sup> Charles Johnson, “Acquisition of the C-17 Aircraft: A Historical Account” (Maxwell AFB, Ala., 1986), xvii.

<sup>3</sup> Jacques Gansler, *Defense Conversion: Transforming the Arsenal of Democracy* (Cambridge, Mass.: MIT Press, 1995), 10.

existing systems. As these legacy systems end their service life, the theater airlift concept will have matured and will ease the transition from Force XXI to the Army After Next.

This paper will explore the Army After Next vision with specific focus on those elements that will require a shift in the emphasis of new logistics considerations. It will then analyze those new requirements to determine their airlift mobility and sustainment implications across the spectrum of future Army operations. These requirements will dictate new capabilities the next generation of theater airlift platforms or systems must possess to support the new Army vision. An evaluation of current capabilities and USAF airlift vision will illuminate gaps between capability and requirements. Finally, I will introduce new theater airlift platform and system concepts and analyze them against the new capability requirements derived from Army After Next operational concepts. In short, this paper will address the question, “What theater airlift capabilities will be critical to support the Army After Next, and which emerging systems provide the best path to achieve such capabilities?”

## **Assumptions and Limitations**

In order to frame the argument appropriately, this paper makes several assumptions. The first is that the Army will not significantly stray from its Army After Next vision. This statement entails subordinate assumptions. As was discussed earlier in this chapter, one of the contributing factors behind the new Army vision is the changing strategic environment and the assumption that such an environment will continue to exist is central to the AAN and this paper.

Another element contributing to the formulation of the AAN is the reduction in defense budgets. We will assume that there will be no radical change in the defense

spending posture of the United States. This does allow for fluctuations due to shifts in the balance of power in Congress and presidential administrations. These changes may shift spending trends, but a new monolithic threat such as the Soviet Union will not emerge to galvanize the nation and stimulate a defense build-up similar to that of the cold war.

Another major assumption is that the current technological trends will continue, and any shortfalls as they relate to the AAN concept will not significantly alter the strategic path. One challenge accompanying long-range planning is to reduce the impact of interim environmental perturbations on the accomplishment of the ultimate aims. This challenge is magnified for the AAN with the unprecedented rate of technological change. As this paper will periodically demonstrate, much of the foundation of the AAN concepts is based on *predicted* technological advances. This paper assumes that even if technology does not completely fulfill expectations, the end result will be a concept that closely resembles the AAN and its requirement for theater airlift.

The success of the AAN concept relies heavily on both strategic and tactical mobility. Several futuristic strategic mobility concepts are worthy of study and debate as they relate to the AAN.<sup>4</sup> Technological advances will allow greater cross-utilization of theater and strategic mobility assets. In order to examine with sufficient depth, this paper is limited to the discussion of future *theater* airlift requirements. Strategic mobility will not be completely avoided, but will be viewed as a secondary advantage in the fulfillment of AAN theater mobility requirements.

---

<sup>4</sup> For example, the Lockheed Advanced Mobility Aircraft, Boeing, USAF Strategic Mobility Aircraft, Trans-Atmospheric Vehicles, Fast Ships.

In investigating and evaluating future airlift concepts and their adequacy in supporting the Army After Next, I will not deliver a detailed cost assessment. This is not to say that cost will be disregarded as a factor when considering options presented in this paper. However, because most of the programs and concepts are still in the “think tank” phase, a detailed cost analysis would be inappropriate. Instead, the criteria by which I will evaluate the adequacy of future airlift systems are mission capabilities. These capability criteria include 1) austere operations, 2) cargo handling capability, 3) situational awareness, and 4) defensive systems.

## **Chapter 2**

### **The Army After Next Concept**

*Where there is no vision, the people perish.*

The Holy Bible: Proverbs – Ecclesiastes 29:18

The Army After Next (AAN) vision is intended to be more than merely a technology-based strategy for future land warfare. It is a holistic conceptual framework designed to reshape methods for the conduct of all future Army operations. Some of these changes will directly affect the airlift capabilities required to support and sustain such an Army. This chapter will present a brief synopsis of the genesis of the AAN concept, describe the fundamental scope of the project and assumptions therein, present a notional force structure, and lay out a rough sketch of the concept of operations in a future employment scenario. This primer is important because it provides the “what” and “how” of future operations as seen by the AAN planners and establishes the foundation for the derivation of theater airlift capabilities necessary to support the vision.

### **Genesis**

In February of 1996, amid the force downsizing, defense budget reductions, and an intimidating Quadrennial Defense Review, U.S. Army Chief of Staff General Dennis Reimer tasked the U.S. Army Training and Doctrine Command (TRADOC) to develop a long range strategic vision. Specifically, he tasked TRADOC to

conduct broad studies of warfare to about the year 2025 to frame issues vital to the U.S. Army after about 2010, and to provide those issues to senior Army leadership in a format suitable for integration into TRADOC development programs.<sup>5</sup>

This tasking signified the birth of the Army After Next project and later became the project's official mission statement. The project rapidly expanded, and by year's end involved more than two hundred planners and representatives from all areas of DoD.<sup>6</sup> This rapid start provided the project with the visibility and legitimacy it needed to leap into such a potentially controversial endeavor.

One of the possible sources of controversy stemmed from the fact that the Army was already pursuing a force modernization program in the Force XXI project. Army planners believed that this effort was not enough to ensure the maintenance of the U.S. Army's status as the world's elite fighting force well into the 21<sup>st</sup> century, and cited three reasons for a new approach.<sup>7</sup> First, Force XXI was designed to integrate new technologies with the current systems. Even with modifications, the systems built in the 1980s will have completed their usable service life by 2010. Second, the pace of technology suggests that it will not only change the military hardware, but the organizations around which it is built. Force XXI initiatives primarily affect information systems and equipment, with significantly less attention paid to structure. Third, the

---

<sup>5</sup> Quoted in Col Robert B. Killebrew, "The Army After Next: Defining Future Landpower Challenges," *Army*, vol. 48 no. 2 (February 1998): 23.

<sup>6</sup> Anne W. Chapman et al., "Prepare the Army for War: A Historical Overview of the Army Training and Doctrine Command, 1973-1998," Chapter 6, "Doctrinal Renaissance," 1998, n.p.; on-line, Internet, 23 February 1999, available from <http://www.tradoc.army.mil/historian/pubs/TRADOC25/chap6.htm>.

<sup>7</sup> Col Robert B. Killebrew, "The Army After Next; TRADOC's Crystal Ball Eyes the Service's Shape Beyond Force XXI," *Armed Forces Journal International*, vol. 134 no. 3 (October 1996): 38.

planners felt that the rapidly changing geopolitical environment will eventually produce one or more “major competitors.” This term intentionally does not mean “peer competitor,” but rather a power that will be strong enough to require something more than obsolescent equipment to challenge it.<sup>8</sup>

## Scope

In an effort to avoid the “technology trap” and develop a comprehensive study, the AAN project organized around four basic research areas: “the geostrategic setting, the evolution of military art, human and organizational issues, and technology trends.”<sup>9</sup>

### Geostrategic Environment

As expected in an endeavor that entails looking to the future, the Army planners were forced to make some assumptions about the nature of the security environment in 2025. Among the most important were

1. The international system will continue to be based on a nation-state power base where sovereignty counts
2. Most armies will continue to exist to fight other armies
3. By 2025, there will be at least one major security competitor<sup>10</sup>
4. As with any assumptions, the validity of the list above is certainly open for debate. However, the inclusion of these assumptions in this paper is solely for the purpose of presenting an accurate framework within which the AAN concepts have emerged.

---

<sup>8</sup> U.S. Army Training and Doctrine Command (TRADOC), *Knowledge and Speed: The 1997 Annual Report on The Army After Next Project to the Chief of Staff of the Army*, July 1997, n.p.; on-line, Internet, 23 February 1999, available at “Papers” from <http://www.tradoc.army.mil/dcsdoc/fbdaan/aamframe.htm>.

<sup>9</sup> Ibid., 1.

<sup>10</sup> Col Robert B. Killebrew, “The Army After Next; TRADOC’s Crystal Ball Eyes the Service’s Shape Beyond Force XXI,” *Armed Forces Journal International*, vol. 134 no. 3 (October 1996): 44.

## **Human and Organizational Issues**

The value of the technological advances and equipment improvements for the AAN will rest heavily on the structure and personnel within which it is designed. With this in mind, the AAN team developed the Army Imperatives, described as “an institutional culture that is receptive to change and a broad framework for managing the change.”<sup>11</sup> Three of the six imperatives (force mix, material, and doctrine) pertain to the organizational constructs, and three (quality people, leader development, and training) address personnel issues.<sup>12</sup>

Among organizational challenges identified by the AAN are “flat” organizations, streamlining producer-to-user distribution systems, and effectively integrating an expanded civilianized/contracted force. These organizational imperatives were developed under the rubric of combat support, where the AAN focuses primarily on efficiency.<sup>13</sup> Research objectives regarding human elements include soldier selection methods, “cognitive congruity” between the digitized systems and human mental structures, and biomedical intervention studies attempting to maximize mental and physical performance.<sup>14</sup>

---

<sup>11</sup> U.S. Army Training and Doctrine Command (TRADOC), *Knowledge and Speed: Battle Force and the U.S. Army of 2025, The 1998 Annual Report on the Army After Next Project to the Chief of Staff of the Army* (Fort Monroe, VA: TRADOC, 1998), 37.

<sup>12</sup> Ibid., 39-41.

<sup>13</sup> See “The Human and Organizational Characteristics of AAN (2025)” within the “Knowledge & Speed” slidepool, 20 February 1999, available at “Briefings” from <http://www.tradoc.army.mil/dcsdoc/fbdaan/aamframe.htm>.

<sup>14</sup> Michael Drillings, “Enhancing Soldier Performance: The Core of Combat Effectiveness” Briefing slide #8, 8 June 98, on-line, Internet, 23 February 1999, available on “SRO Briefings” at “Projects” from <http://www.tradoc.army.mil/dcsdoc/fbdaan/aanframe.htm>.

## **Evolution of Military Art**

Military art applies to the entire realm of warfare from the strategic planning to the tactical application. The AAN focus is primarily operational art, which is subsumed by military art. Operational art is the ability to integrate “key activities at all levels of war” and ensure that tactical victories lead to the attainment of strategic objectives.<sup>15</sup> With this in mind, the AAN project team identified “evolution of military art” as one of the four focused research areas. This area addresses the application of principles of war in ways that maximize the potential of emerging technologies within the projected future geostrategic environment.<sup>16</sup> The primary elements that make up this link between technology and the environment are the characteristics of the force structure and the concept of operations.

The AAN Hybrid Force Idea Integration Team (ITT) was created to conduct research into both future force structure and operational concepts. This team conducts feasibility assessments of AAN concepts based on emerging technological advances. It also works with science and technology organizations such as DARPA, the Army Research Lab, and industry experts to exploit new technologies and create “spin-on” military capabilities. Such coordination aids in redefining force structure and characteristics. In addition, the Hybrid Force IIT investigates future concepts of force employment to include fires support, mounted and dismounted operations, and maneuver support.<sup>17</sup> By continuously

---

<sup>15</sup> Joint Pub 3-0, *Doctrine for Joint Operations*, 1 February 1995, GL-10.

<sup>16</sup> For a list of accepted Joint Principles of War, see Joint Pub 3-0, II-1.

<sup>17</sup> Col James G. Bray, “Army After Next Hybrid Force IIT,” briefing, 4 January, 1999, n.p.; on-line, Internet, 22 February 1999, available at “Hybrid Force IIT Project Room” at “Projects” from <http://www.tradoc.army.mil/dcsdoc/fbdaan/aanframe.htm>.

updating and refining concepts against the backdrop of an evolving new strategic environment, the AAN is attempting to account for unpredictability in the face of unanticipated technological advances. As a senior TRADOC staff officer put it,

With technological progress, organizational changes are (or should be) inevitable.....It is not proven that organizations and doctrine based on the M1A2 tank will be obsolete by 2020; it seems prudent, though, to forecast what effect emerging technologies might have on the way the future Army fights.<sup>18</sup>

## **Technology Trends**

While making a concerted effort to develop a comprehensive long-term vision, the Army After Next team realizes that technological advances will be necessary in order to bear the fruit of such bold thinking.<sup>19</sup> One risk inherent in staking a long range plan on something as unpredictable as technology is the potential cost of being wrong. This possibility is very real for the AAN. In an attempt to mitigate such an eventuality, the AAN team has taken steps beyond pursuing traditional hardware improvements, and seeks out emerging technologies that exploit advantages in operational concepts as well as tactical engagements. The annual reports to the Army Chief of Staff clearly define the two central themes of the AAN as *knowledge* and *speed*. To support these themes, there

---

<sup>18</sup> Col Robert B. Killebrew, "The Army After Next; TRADOC's Crystal Ball Eyes the Service's Shape Beyond Force XXI," *Armed Forces Journal International*, vol. 134 no. 3 (October 1996): 37.

<sup>19</sup> TRADOC, "Technology: The Path to Knowledge and Speed." *Knowledge and Speed: The 1997 Annual Report on The Army After Next Project to the Chief of Staff of the Army*, July 1997, n.p.; on-line, Internet, 23 February 1999, available at "Papers" from <http://www.tradoc.army.mil/dcsdoc/fbdaan/aamframe.htm>.

are three main areas in which technology is being actively pursued: information systems, materials, and logistics capabilities.<sup>20</sup>

One technological category that the AAN is most dependent upon (and appears most blissfully optimistic about) is information systems. Exploitation of information technology is the cornerstone of the AAN concept, as well as the joint vision. The AAN definition of *information dominance* coincides exactly with the Joint Vision 2010 definition of *information superiority*: “The capability to collect, process and disseminate an uninterrupted flow of information while exploiting or denying an adversary’s ability to do the same.”<sup>21</sup> In this arena, the AAN project is pursuing technologies that will acquire and process significant amounts of information, and robust capabilities to minimize vulnerabilities. For example, while the future intelligence, surveillance, and reconnaissance (ISR) systems will integrate heavily with space-based assets, the AAN is pursuing alternative concepts such as advanced UAV and anti-UAV technologies to ensure information dominance in an environment in which space systems have been degraded.<sup>22</sup> Such redundant systems are intended to protect the “unblinking eye” of surveillance against potential asymmetric threats, thus preserving the information advantage.<sup>23</sup>

---

<sup>20</sup> TRADOC, *Knowledge and Speed 1998*, A-6, A-7.

<sup>21</sup> Ibid., 23. See also Joint Chiefs of Staff, *Joint Vision 2010* (Washington, D.C.: Joint Chiefs of Staff, 1995), 10.

<sup>22</sup> Ibid., 25.

<sup>23</sup> TRADOC, *Knowledge and Speed 1997*, available from <http://www.tradoc.army.mil/dcsdoc/fbdaan/aamframe.htm>.

Data correlated becomes information. Information converted into situational awareness becomes knowledge. Knowledge used to predict the consequences of actions leads to understanding. Thus the cognitive hierarchy.<sup>24</sup>

In order to provide the necessary situational awareness, the AAN project is investing in “advanced information processing, employing automatic filters, decision support aids, comparative analysis, and distributed by multiple communications routes, …the means by which information is turned quickly into knowledge.”<sup>25</sup> Such an investment might indeed be worthwhile, but the goal of turning information into knowledge might be somewhat lofty. As one Army officer who played the on the enemy “red” team in an Army After Next war game put it,

Even with a dramatic improvement in the ability to “see” the battlefield, it will remain possible to “show” a course of action and then do something else. Time, speed, and distance factors will then determine if the target of the deception can react fast enough to counter the true intent.<sup>26</sup>

Materials technology investments have many different applications in the AAN vision, but the primary product is weight reduction. The mission need statement the Army presented in 1996 for an Abrams tank replacement called for a forty- percent weight reduction.<sup>27</sup> To achieve such a reduction while maintaining sufficient protection will require significant advances in composite materials. The smaller Advanced Fighting Vehicle concept will also exploit materials technology, not only in its lighter weight (15 –

---

<sup>24</sup> Jeffrey Cooper, “DBK and Future War,” in *Dominant Battlespace Knowledge*, ed. Stuart E. Johnson and Martin C. Libicki, (Washington D.C.: NDU Press, 1996), 89.

<sup>25</sup> TRADOC, *Knowledge and Speed 1998*, 24.

<sup>26</sup> Col. John M. House, “The Enemy After Next,” *Military Review*, vol. LXXVII no. 2 (March/April 1998): 23.

<sup>27</sup> Jason Sherman, “21<sup>st</sup> Century Tank,” *Armed Forces Journal International*, vol. 134 no. 3 (October 1996): 48.

20 tons), but also through the use of low observable technology.<sup>28</sup> As information technologies most directly support the central theme of “knowledge,” so material technology supports “speed,” especially when coupled with advances in propulsion. With more power underneath a lighter frame, the goal of the Advanced Fighting Vehicle is a 120-kph road speed.<sup>29</sup> In addition to power, the AAN is looking for propulsion technology to provide efficiencies well beyond current systems. Assuming they are achievable, such efficiencies can significantly reduce the logistics tail required for force sustainment.

Changes in the strategic environment resulting in reduced forward basing capability highlight the importance of a more streamlined logistics system with a smaller footprint. The changes required are so broad and sweeping, the concept of a “revolution in military logistics” (RML) has been accepted as a prerequisite for achieving the desired capabilities of the AAN.<sup>30</sup> Investigations into future logistics requirements primarily focus on the logistics principles of responsiveness, sustainability, and survivability.<sup>31</sup>

Responsiveness, or providing “the right support in the right place at the right time,”<sup>32</sup> presents a greater challenge to a largely CONUS-based force than to one that is forward-deployed. Providing the right support to the right place requires knowledge of the location and status of supplies and weapons systems. The AAN is pursuing advances

---

<sup>28</sup> Col Bourgoine, “AAN FY98 Insights Brief,” 24 February 1999, slide #22, on-line, Internet, 28 February 99, available from “Briefings” at <http://www.tradoc.army.mil/dcsdoc/fbdaan/aanframe.htm>.

<sup>29</sup> Ibid.

<sup>30</sup> TRADOC, *Knowledge and Speed 1998*, 28.

<sup>31</sup> For a list of Joint Principles of Logistics, see Joint Pub 4-0, *Doctrine for Logistic Support of Joint Operations*, 27 January 1995, II-1.

<sup>32</sup> Ibid.

in information technology and refinement of Total Asset Visibility (TAV) projects currently underway to provide this knowledge.<sup>33</sup> Merging this concept with the organizational imperative regarding “flattening” the command structure, the project is looking to new technologies such as “brilliant” computer cards and database replication to push logistic situational awareness down to the soldier level.<sup>34</sup> Determination of the appropriate level of information throughout the chain of command will be necessary to make this “flattening” effective.

Providing the support at the right time requires agile system capable of rapid response. Many of the technological endeavors in the fields of materials and propulsion will have a direct impact on logistics. Any system that can be made lighter can be more easily transported. Likewise, reducing the size of equipment provides the opportunity to move more of it by a given mode of transportation. The pursuit of weight reduction in fighting vehicles, precision munitions, and power sources supports a more effective logistic system while enhancing maneuverability. Such advances in materials and propulsion will not only affect the fighting equipment, but the systems designed to transport them as well.

A logistian that cannot keep up or see the friendly forces, cannot adequately support. If the combat platforms dramatically increase in speed and maneuver, support vehicles must have commensurate improvement. The two systems are inextricably linked.<sup>35</sup>

---

<sup>33</sup> TRADOC, *Knowledge and Speed* 1998, B-9.

<sup>34</sup> Ibid., B-12.

<sup>35</sup> Col. Gary J. Motsek (USA), “Logistic Support to the Army After Next Warfighters: A Time for Fundamental Change,” in *AY 97 Compendium Army After Next Project*, ed. Douglas V. Johnson, II (Carlisle, PA: Strategic Studies Institute, 1998), 96.

With this in mind, the AAN has spelled out the need for speed and mobility in its tactical combat support elements, as well as enhancements in ultrafast sealift and airlift. “Although the Army is not directly responsible for the last two, no service has a greater interest in them.”<sup>36</sup>

Technologies related to responsiveness and sustainability are complementary in nature. Fossil fuel improvements and alternatives, lighter armor and automotive materials, and lighter precision munitions not only reduce the logistic footprint, but also provide for greater efficiency and reduced sustainment requirements. To enhance sustainability further, the AAN project is addressing maintenance issues through the concept of “ultrareliability” needed to support the fielded forces. The goal of this concept is to give the operators of all systems the capability to repair most equipment. This will require on-board spares and technical instructions for repair work. The technology piece to this puzzle consists of developing “capabilities for anticipatory maintenance-self-diagnostics, programmable sensors, failure warning, etc.”<sup>37</sup>

Survivability implications of combat equipment on the logistics system are apparent. The longer a system can last in combat, the less will be the ongoing sustainment requirements. The AAN is pursuing technologies in low observable material, active protection systems, and advanced missile defense systems to enhance system survivability.<sup>38</sup> However, as a principle of logistics, survivability speaks to the “capacity

---

<sup>36</sup> TRADOC, *Knowledge and Speed 1997*, available from <http://www.tradoc.army.mil/dcsdoc/fbdaan/aamframe.htm>.

<sup>37</sup> TRADOC, *Knowledge and Speed 1998*, 29.

<sup>38</sup> *Ibid.*, A-6.

of the [logistics] organization to prevail in the face of potential destruction.”<sup>39</sup> The best way to ensure survival is to keep critical components of the system out of harm’s way.

Although the United States should enjoy dominant battlefield awareness, there is a recognition that centers of gravity and critical points need to be reduced. For logisticians, this will provide additional incentive to avoid large static piles of material within the battlespace. Tactical and operational logisticians will “reach back” as far as necessary, even to the CONUS base, to fulfill requirements while keeping the battlespace logistical footprint small.<sup>40</sup>

Coming full circle, this aspect of survivability must compete with the principle of responsiveness. The AAN seeks advances in airlift, coupled with increased logistical situational awareness to provide the projection and sustainment capabilities, while decreasing system exposure to attack.<sup>41</sup>

### **Force Structure – The Hybrid Force**

The hybrid force of 2025 will be forged from a range of functions, force structures, and capabilities spanning 20-25 years, from modernized AOE [Army of Excellence] organizations to AAN battle forces, each optimized for a specific set of missions and circumstances, but adaptable to meet a broad range of conditions.<sup>42</sup>

One of the primary threads running through the Army After Next vision is the necessity to integrate force structure through the age of rapid technological change. In doing this, there is a risk of limiting potential through incremental change. To avoid such

---

<sup>39</sup> Joint Pub 4-0, II-3.

<sup>40</sup> Motsek, 99.

<sup>41</sup> TRADOC, *Knowledge and Speed* 1998, 19, 36.

detrimental compromise, the AAN has conceptualized the future force structure by dividing it into three discrete entities. The Army of Excellence (AOE) represents the current force structure. Force XXI is a projected force structure for the 2010-2015 time frame. The AAN force is planning to make its concept fully operational by 2025. The distinguishing features of each are the technology-enhanced capabilities and the operational concepts by which the force will be employed. The AAN project monitors the developments of each and contributes to the integration of concepts. The ultimate goal is to maximize the capabilities of the hybrid force at every stage of its development.

The AOE force structure of the present day is largely a product of the modernization program of the 1980s. Developed during the cold war era, the force emphasizes mass and overwhelming firepower. With the technology of the time, these characteristics of the mechanized force came at the cost of maneuverability and strategic mobility. With the abundance of forward basing at the time, strategic mobility was not a significant issue. The present force has made technological advances, but must be lighter and more strategically mobile if the United States is to continue with its policy of engagement.

Force XXI “aims to exploit information technologies in order to fight more efficiently and maintain higher performance levels in both good conditions and bad.”<sup>43</sup> Advanced Warfighting Experiments (AWEs) such as the “digitization of the battlefield” have been underway for several years, and are yielding results that will enhance future

---

<sup>42</sup> Ibid., 16.

<sup>43</sup> “Land Forces,” *Strategic Assessment 1996: Elements of U.S. Power*, n.d., n.p.; on-line, Internet, 23 February 1999, available from <http://www.ndu.edu/inss/sa96/sa96ch14.html#subhead2>.

systems.<sup>44</sup> These systems, which will be lighter and faster than the current AOE structure, are designed to integrate into a comprehensive operational concept. The idea is to make Force XXI “more of a process than a ‘force’ in that the incorporation of information technologies opens the door to new and innovative ways to perform military tasks.”<sup>45</sup> Force XXI will attempt to bridge the gap between aging AOE systems and newly arriving AAN systems.

The AAN force structure represents the final stage of the metamorphosis. The planners hope is to field elite forces possessing capabilities made possible by technologies either just now emerging or not yet existent. Such forces will have strategic strike capability, accompanied by exceptional speed and lethality. These will be known as the Battle Forces.<sup>46</sup> The most capable Force XXI forces will provide second echelon strength of the AAN. These medium weight assets will be the maturing systems fielded in the 2010 time frame, and make up the Strike Forces.<sup>47</sup> The leading edge of today’s force structure will comprise the heaviest system, requiring the greatest logistics and sustainment requirements. These forces will serve as the Campaign Forces in the AAN

---

<sup>44</sup> For a review of the digitization AWE, see Mark Hanna, “Task Force XXI: The Army’s Digitization Experiment,” in *Strategic Forum, Institute for National Strategic Studies*. No. 119, July 1997, n.p.; on-line, Internet, available from <http://www.ndu.edu/inss/strforum/forum119.html>.

<sup>45</sup> Earl H. Tilford, reviewing the paper of General David M. Maddox, USA, *National Defense Into the 21<sup>st</sup> Century: Defining the Issues*, 6 June 1997, n.p.; on-line, Internet, 22 February 1999, available from <http://carlisle-www.army.mil/usassi/ssipubs/pubs97/natdefns/defnsp2.htm>.

<sup>46</sup> TRADOC, *Knowledge and Speed 1998*, 17.

<sup>47</sup> *Ibid.*

concept of the hybrid force.<sup>48</sup> Each will fulfill a specific role in the projected concept of operations in 2025.

## **Concept of Operations**

The AAN is developing an operational concept for its hybrid force that will provide significant effectiveness throughout the life cycle of a conflict. This concept is elaborated through the six “patterns of operations” developed by TRADOC to characterize land combat in the 21<sup>st</sup> century.<sup>49</sup> These patterns, *project the force, protect the force, gain information dominance, shape the environment; set conditions for success, conduct decisive operations, and sustain the force* are “mutually supportive and nonsequential. They are conducted simultaneously and continuously through all phases of conflict.”<sup>50</sup> It is within each of these patterns that the AAN seeks advantages.

## **Project the Force**

From the end of World War II to the end of the cold war, the Army’s ability to project the force was facilitated by the availability of forward basing. Today’s environment does not allow for such forward presence, forcing the Army to deploy largely from CONUS. To account for this, the AAN is developing the concept of revolutionary strategic mobility. Its technology strategy is in line with this, as its weight reduction would reduce the strategic airlift burden. In addition, the AAN is pushing for technologies in fast ships and ultraheavy airlifters to assist in the force projection role.

---

<sup>48</sup> Ibid., 18.

<sup>49</sup> “Characteristics of Force XXI Operations,” *Land Combat in the 21<sup>st</sup> Century*, n.d., n.p.; on-line, Internet, 24 February 1999, available from <http://www-tradoc.army.mil/text/landcmbt.htm>.

The Battle Forces will be the first elements deployed, arriving rapidly with the lethality and maneuverability designed to accomplish “strategic preclusion” (deterring further provocative action by a demonstration of will and capability). This potential flexible deterrent option cannot be accomplished organically, and the AAN realizes that “the primary responsibility for projecting the Army of 2025 will rest solidly on advanced deployment capabilities resident in the U.S. Air Force and Navy.”<sup>51</sup> For success, such a scheme would necessitate an expeditionary mindset, and require either a radical reduction in logistics buildup or tremendous strategic mobility.

The Strike Forces will follow the Battle Forces during projection. These will not be as nimble, but the technologies forged during the Force XXI era will produce a combat capability with high maneuverability and a lean logistics tail. These forces will assist the Battle Forces in shaping the environment. Finally, the Campaign Forces will arrive in theater to present the increased strength and staying power to the hybrid force.

## **Protect the Force**

To accomplish this difficult task, the AAN is placing emphasis on information systems from human intelligence to complex ISR capabilities. These systems will allow the AAN to identify potential asymmetric threats against vital systems. In addition, planners are calling for an improved missile defense system to mitigate WMD threats, claiming “*For U.S. Joint Forces in 2025, few technological challenges will be as important as creating an effective missile defense*” (emphasis in the original).<sup>52</sup>

---

<sup>50</sup> TRADOC, *Knowledge and Speed 1998*, 19.

<sup>51</sup> Ibid., 20.

<sup>52</sup> Ibid., 22.

## **Gain Information Dominance**

This area is critical because information dominance must not only be attained, but also *maintained*. The multi-layered systems that are proposed present daunting tasks of fusing, processing, analysis, and dissemination. Through this network of systems, there must be multi-layered situational awareness. This means the decision-makers must know if they are operating in an environment of information dominance. If they are not, they must be aware of which information systems are under attack, and adjust their perception of operations accordingly.<sup>53</sup>

## **Shape the Environment; Set Conditions for Success**

This pattern is suited for all phases of conflict. As a potential conflict emerges, Special Operations Forces (ARSOF) will be uniquely qualified to operate within the specified region and be a valuable resource to the Joint Force Commander. During pre-hostilities, the rapid deployments and demonstrations of force will be exercised to improve the chances of strategic preclusion as well as for battle preparation. During combat operations, the AAN foresees operations to maintain dominance in all areas, with special emphasis on information and degradation of the enemy's precision strike capability.<sup>54</sup>

## **Conduct Decisive Operations**

Through the force projection strategy, the AAN plan is to be postured to take advantage of opportunities for swift and decisive victory, but to prepare for extended

---

<sup>53</sup> Ibid., 23.

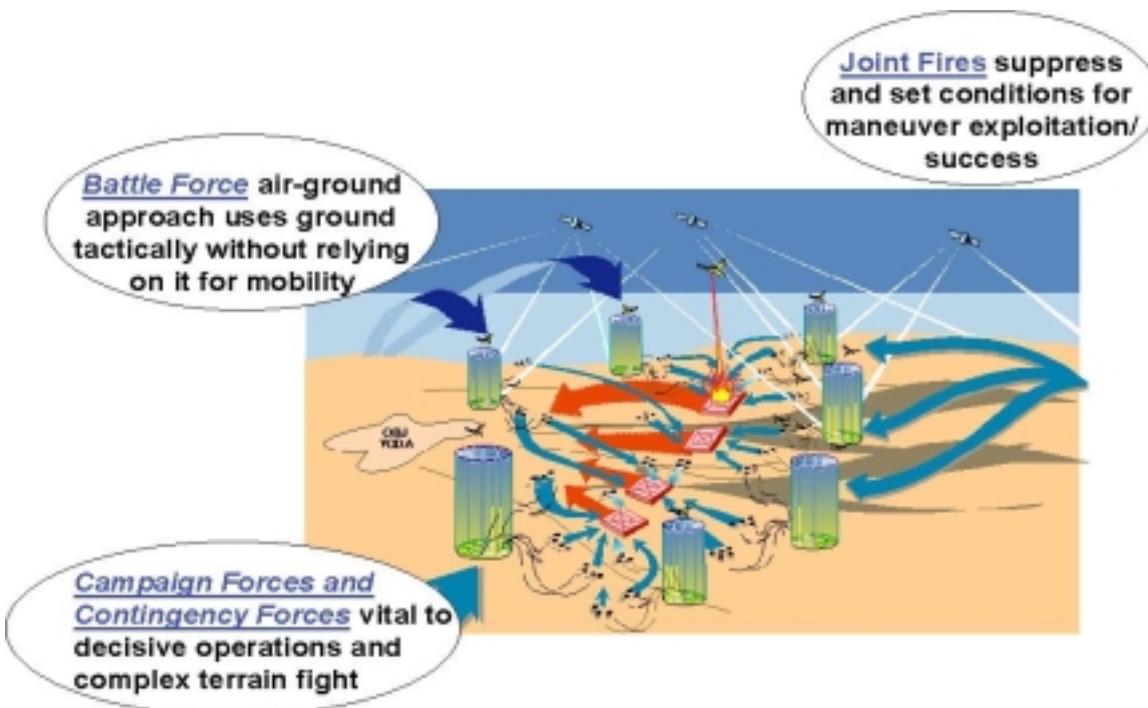
<sup>54</sup> Ibid., 25.

operations. Extended operations do not mean attrition warfare. In fact, one of the underlying premises of the AAN is that due to the preponderance of high value assets, attrition warfare must be avoided.<sup>55</sup> In extended conflicts, Campaign, Strike, and Battle Forces will operate synergistically against enemy objectives. Information dominance will provide the commanders a picture of enemy positions and capabilities, giving them the advantage of directing each element against the types of objective for which it is best suited. Figure 1 illustrates the way in which several combat elements can be positioned to provide strike potential against several different objectives.

**Figure 1. Decisive Operations Across the Battlespace**

---

<sup>55</sup> Col Robert B. Killebrew, “The Army After Next; TRADOC’s Crystal Ball Eyes the Service’s Shape Beyond Force XXI,” *Armed Forces Journal International*, vol. 134 no. 3 (October 1996): 45.



Source: TRADOC briefing slides, on-line, Internet, 5 March 1999. Available from <http://www.monroe.army.mil/dcsdmc/fbdmc/briefings/ann/annslidepool/neuvaodule/knowledge&speed.ppt>

The most capable units of this hybrid force will be the Battle Forces. These forces will possess an unprecedented combination of maneuver and lethality. This is made possible primarily through near vertical maneuver.

At the tactical level, AAN research indicates that speed must be increased by a factor of two or more to overcome the strength of a knowledge- and precision-based defense...achieving this level of improvement will only be possible by rotating the traditional two-dimensional orientation of forces into the vertical dimension.<sup>56</sup>

When combined with information dominance, this increased tactical mobility provides the foundation for a new, nonlinear battlespace environment. Small maneuver units will possess the advantages of traditional concept of mass (increased lethality), without its traditional drawbacks (lack of agility). One other vulnerability commanders

<sup>56</sup> TRADOC, *Knowledge and Speed* 1998, 15.

will be able to mitigate is exposure. The maneuverable Battle Forces will be dispersed, thus decreasing the probability of detection. Through enhanced battlespace awareness, the commander can synchronize the forces, mass combat effects, and disperse the units to increase survivability. Through the successful orchestration of move-strike-move throughout the battlespace, “Battle Force operations will resemble an ambush dynamic.”<sup>57</sup>

## **Sustain the Force**

The success of sustaining the Army After Next operations will depend heavily on the much-needed revolution in military logistics. The AAN planners are attempting to tackle the problem in two ways: increase the efficiency *of* the logistics system and decrease the requirements *for* logistics. Efforts for increased efficiency include improved command and control systems and better in transit visibility. Both of these pursuits will rely on information technology improvements to achieve the desired capabilities, and information dominance to maintain those capabilities during AAN operations.<sup>58</sup> The importance of logistics efficiency to operational success and the dependence on unproven capabilities highlight the risk involved in formulation of the AAN concept.

Sustaining the Battle Forces of the AAN will also present unique challenges. In order to increase survivability, the ground forces will be dispersed when they are not engaged. The airlift system responsible for maneuvering the units will become the primary line of resupply at the dispersed locations.

---

<sup>57</sup> Ibid., 27.

<sup>58</sup> Ibid., 29.

The constant massing and demassing of forces is possible only with the maturation of the operational concepts of *Joint Vision 2010* and the necessary technology. It suggests that the bulk of critical logistical support (fix, fuel, arm) are provided during those times when the battle force is demassed. It suggests that logistical support forces will have many of the characteristics of the battle forces.<sup>59</sup>

One such characteristic is increased survivability. Future resupply operations will be conducted throughout the battlespace, not confined to the safe areas on the friendly side of the FLOT (forward line of troops) as is the case with current doctrine.

## Conclusions

The Army After Next concept is a far-reaching vision that relies heavily on emerging technologies. To the planners' credit, they have realized that technology is only as good as the system in which it operates. With this in mind, the AAN team has created a vision for the entire system, to include the world in which the technologies will exist (geostrategic environment), the use of the technologies (evolution in military art), as well as the users (human and organizational issues). With these primary areas of interest in mind, the AAN project is attempting to provide a path for successful application of landpower in support of national objectives well into the 21<sup>st</sup> century.

As holistic as this concept may be, it is still heavily dependent on technology for its success. Among the major areas of technological pursuit are information systems, materials and propulsion, and logistics. As the concepts of operations evolve, the logistics concepts must evolve with them. Advances in the conduct of patterns of operations by light, lethal Battle Forces allow orchestrated concentration and dispersal

---

<sup>59</sup> Motsek, 102.

during combat operations. These advances drive new sustainment requirements for those forces. The following chapter identifies those requirements as they relate to theater airlift.

## Chapter 3

### Army After Next Implications for Theater Airlift

*Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.*

—Giulio Douhet

The Army After Next concept developers envision a significant transformation in the composition of forces and the makeup of the battlespace. Despite this, the fundamental logistics function of “planning and executing the movement and sustainment of operating forces in the execution of a military strategy and operations”<sup>60</sup> will still exist. In fact, it is very likely that the future challenges will be greater. The increased complexity of the environment will demand a sophisticated logistics support structure in which precision and anticipation will take the place of stockpiling and surplus. The nature of the changes that must occur for implementation of the theater airlift piece of this new logistics system is derived from the changes that will take place in operational employment of the AAN hybrid force.

The concept of vertical envelopment is a shift in operational employment that will require a significant change in logistical support. Vertical envelopment involves using airborne assets to transport combat forces rapidly into positions most advantageous for massing fires. Primarily, the Battle Forces will accomplish this movement, allowing

---

<sup>60</sup> Joint Pub 4-0, *Doctrine for Logistic Support of Joint Operations*, 27 Jan 95, I-1.

them to “use ground tactically without relying on it for mobility.”<sup>61</sup> Reorienting maneuver into the third dimension implies moving entire fighting units. Granted the Battle Forces will have a significantly better weight to firepower ratio than the current force, but such a shift in transportation medium will put substantially more reliance on airlift. This represents an expansion of current air assault operations and the role theater airlift will play in combat maneuver.

In order to accomplish vertical envelopment, airlift must be able to place the Battle Forces at or near the required location to optimize fire synchronization and effects massing. Because the objective areas will often lie in regions far from prepared runways, the airlift system must be sufficiently robust to deliver combat power to very austere locations.

By its very nature, dispersal places an increased burden on resupply efforts. Though each element requires fewer supplies, there are more destinations to support. Airlift doctrine currently proposes a “hub and spoke” concept in which supplies are delivered strategically to a single location, then distributed throughout the theater as needed.<sup>62</sup> Future sustainment operations will require a system in which a single platform can deliver to several operating locations throughout the battlespace. Such an employment concept implies an increased exposure time to the sustainment platform. Also, the dynamic nature of the future battlespace will necessitate greater flexibility on the part of

---

<sup>61</sup> Col Bourgoine, “AAN FY98 Insights Brief,” 24 February 1999, slides #7,8, on-line, Internet, 28 February 99, available from “Briefings” at <http://www.tradoc.army.mil/dcsdoc/fbdaan/aanframe.htm>. Also see *Knowledge and Speed: Battle Force and the U.S. Army of 2025, The 1998 Annual Report on the Army After Next Project to the Chief of Staff of the Army*, 15.

the delivery system to account for situational changes that may occur during mission execution.

As previously stated, the changes in operational concept in the AAN do not alter the fundamental requirement for logistical support. The principles of logistics as described in *Joint Pub 4-0* will remain valid. *Responsiveness* will continue to be the keystone, but *survivability* and *flexibility* in airlift operations will increase significantly in importance.<sup>63</sup> These logistics principles can also be defined as characteristics of an effective theater airlift support system. In evaluating airlift platforms, it is useful to identify capabilities required to exhibit the desired characteristics of the system. This paper will identify and analyze four capabilities: 1) austere operations, 2) cargo handling capability, 3) situational awareness, and 4) defensive systems.

## **Austere Operations**

Aircraft operations were born in an austere environment. The Wright brothers first took flight in a field at Kitty Hawk. The very name “airfield” implies a patch of pasture that accommodates airplanes. The evolution of propulsion technology and airfoil design brought with them the promise of increased lift capability. The demand for more payload capacity expanded at a greater rate than propulsion and wing technology, requiring increased takeoff and landing distance. Largely because of this phenomenon, the airfield has grown from a piece of open and cleared land to the 15,000 foot runways with

---

<sup>62</sup> Air Force Doctrine Document 2-6, *Air Mobility*, 24 February 1999, 50; on-line, Internet, 14 March 1999, available from <http://www.hqafdc.maxwell.af.mil/Library/Doctrine/afdd2-6.pdf>.

<sup>63</sup> For accepted Joint Principles of Logistics, see *Joint Pub 4-0*, II-1 – II-4.

sprawling concrete taxi and parking areas built to support the intercontinental bomber force.

As airfields grew in size and complexity, they developed an inherent weakness. The combination of high value assets and a fixed location made them lucrative targets. Early airpower theorists such as Giulio Douhet recognized the importance of attacking the enemy air forces on the ground in an effort to “kill the eggs in the nest.”<sup>64</sup> AAN theater airlift operations at austere locations will reduce this vulnerability, as airfields will be temporary and will resemble those in use during the infancy of powered flight. Two specific capabilities will be required for aircraft to succeed in operations at austere locations: super short takeoff and landing (SSTOL) capability and the ability to identify adequate opportune landing sites (OLS).

### **Super Short Takeoff and Landing (SSTOL)**

The call for a theater transport aircraft with reduced runway requirements went out long before the development of the AAN concept. The C-130 has been the mainstay of theater airlift throughout its service life. Experiences in Vietnam illustrated the value of the payload capacity of the C-130 and the desire to operate out of smaller airfields.<sup>65</sup> In the early 1980s, the persistence of low intensity conflict throughout the world called attention to the importance of tactical airlift. This was especially evident in the development of AirLand Battle Doctrine. In studying such airlift requirements, “exceptional takeoff and landing performance” was identified.

---

<sup>64</sup> Giulio Douhet, *Command of the Air* (New York: Coward-McCann, 1942. Reprint, Office of Air Force History, 1983), 53.

<sup>65</sup> George F. Hunter, “An Analysis of V/STOL Heavy Lift Logistics for the 1970’s” (Maxwell AFB, Ala., June 1968), 46.

Under today's emerging doctrine and even more so under future concepts, the need to rapidly move and resupply units and their equipment on a battlefield indicates that the flexibility of landing at almost any location will probably be a high priority requirement.<sup>66</sup>

Through the demise of the cold war, several studies concerning future tactical airlift also identified the need for significant improvements in runway performance. The assumptions about future operations that drove these recommendations were similar to those envisioned by AAN planners: nonlinear battlespace, increased dependence on maneuver, and deep strike operations.<sup>67</sup>

Though the concept of SSTOL is relatively easy to grasp, the capability is more difficult to quantify. Runway requirements for conventional airlift aircraft vary with gross weight. Aircraft advertising short takeoff and landing (STOL) capability claim operational capabilities on runways of approximately 1,500 feet. SSTOL provides a measure of significant distinction between STOL and VTOL (vertical takeoff and landing). Runway distance requirements for aircraft in this category vary, but for this thesis SSTOL capability will be associated with runway operations into locations of less than 1,000 feet.

From a pure logic standpoint, it would appear that SSTOL is still a second-best solution to VTOL transport. VTOL is not new to the airlift world, and has been an

---

<sup>66</sup> Roy C. LeCroy, "Implications of Changing Combat Doctrine and Evolving Threats on Future Tactical Airlifter Requirements" (Maxwell AFB, Ala.: Air War College, 1985), 23.

<sup>67</sup> See North Atlantic Treaty Organization, "Progress in Military Airlift" (Flight Mechanics Panel Symposium, France: AGARD, 1990), 3-1. R.E. Helmeth et al., "Analysis of Tactical Transportation: Progress and Challenges" (paper for

integral part of land combat mobility and sustainment in the form of the helicopter. The CH-47D Chinook (and MH-47E variant) serves as the current frontline Army transport helicopter. It is a very capable platform, able to lift over 36,000 pounds of fuel and cargo.<sup>68</sup> The V-22 Osprey is the newest V/STOL aircraft, able to lift a fuel and cargo load of nearly 44,000 pounds.<sup>69</sup> Though each of these aircraft has formidable lift capacity to support current operations, they possess neither the required cargo compartment dimensions nor the lift capability to support the Army After Next concepts of maneuver and sustainment. Changing the body shape and increasing the shaft horsepower required to improve the lift capacity on propeller-powered VTOL airframes have significant implications for disc loading on the propellers and foreign object damage due to increased downwash.<sup>70</sup> SSTOL offers the promise of fulfilling the Army's future requirement to deliver 30 tons into a runway of 750 feet or less without the added difficulties associated with vertical lift operations.<sup>71</sup> One disadvantage accompanying a SSTOL option is that the need for a ground roll necessitates a degree of smoothness and firmness on the landing site not required for VTOL operations. Such a requirement increases the difficulty in identifying suitable landing surfaces.

---

Defense Systems Management College, 1988), 10-1. Boeing, *Advanced Theater Transport Mission Analysis Study*, 1987.

<sup>68</sup> “Aerospace Source Book: Rotary-Wing Outlook/Specifications,” *Aviation Week & Space Technology*, 11 January 1999, 78.

<sup>69</sup> *Ibid.*

<sup>70</sup> For information on propeller disc loading and downwash, see T. D. White, “V/STOL Aircraft Characteristics Affecting Behavior of Supporting Surfaces” (U.S. Army Material Command, July 1967), 8-10. For information on helicopter body design, see R. W. Prouty, *Helicopter Aerodynamics* (Potomac, MD: Phillips Publishing, Inc, 1985), 87.

## Opportune Landing Sites

Finding a patch of land the right size to accommodate takeoff and landing is essential, but it represents only part of the solution to austere operations. In order to be suitable, the surface at the site must have certain characteristics. One that is critical to safe operations is the absence of any significant obstacle along the takeoff and landing area. Such an obstacle could pose a threat to the landing gear system and render the aircraft inoperable.<sup>72</sup> In unprepared landing areas, obstacles might not be readily visible, especially in areas with low-lying vegetation. Such an obstacle does not have to be prominent to be harmful.<sup>73</sup>

In addition to obstacles, the type and condition of the soil is of paramount importance. Soil that has a large amount of silt will not withstand the aircraft's weight as well as a hard packed surface, and will cause it to sink slightly. This results in a larger surface around the tires, increasing the coefficient of friction and requiring more power (and distance) to achieve takeoff speed. Currently, the standard unit of measurement for aircraft weight bearing capacity of surfaces is known as the California Bearing Ratio

---

<sup>71</sup> TRADOC, Pamphlet 525-66, *Future Operational Capability TC 97-004. Super Short Takeoff and Landing (SSTOL)*, n.d., n.p.; on-line, Internet, 6 March 1999, available from <http://www-tradoc.army.mil/tpubs/pams/p525-66e.htm>.

<sup>72</sup> This threat is exacerbated at higher gross weights. The increase in downward force caused by the added weight, coupled with the increase in landing speed required for heavier gross weights increases the sheer stress on the landing gear when striking an obstacle.

<sup>73</sup> During dirt runway performance testing in early 1997, a C-17 flight test crew landed short of the semi-prepared surface. Though the area 500 feet prior to the landing zone was inspected for obstacles, the aircraft struck a boulder protruding less than one foot above the surface in the grassy area. The result was damage to the right main gear assembly, grounding the aircraft for over three months and evoking a "Class A" accident investigation. For more information on the accident, contact the Air Force Flight Test Safety Office, Edwards AFB, CA.

(CBR). In order to ensure safe operations at austere locations it will be necessary to obtain the CBR or an equivalent to assess site adequacy.<sup>74</sup>

Information on the suitability of austere locations will be required on relatively short notice. It would be ideal to have an existing, accurate global database on hand for operational planning and execution. In reality, such an idea is not feasible for several reasons. First, creation of a database to include all (or even most) potential sites would most likely be cost prohibitive. Second, potential future enemies would certainly balk at the idea of a U.S. site survey for combat support operations on their sovereign territory. Third, the value of such a prepackaged database would be diminished over time. Seasonal climatic changes, precipitation, animal migratory behavior, and manmade activities are but a few of the variables that would require frequent updates. Therefore, the analytical tools must be in place to respond quickly to changes in the prosecution of the battle. The identification of several potential suitable landing sites based on the existing disposition of forces and scheme of maneuver will provide the commander more flexibility in operational decision making.

## **Cargo Handling Capability**

In order to exploit the advantages of gained through austere airfield operations, cargo delivery systems must be both fast and efficient. The ultimate measure of merit in sustainment operations is safe, timely delivery. Resupplying AAN forces in dispersed locations will present significant challenges for future theater airlift forces. Aircrews can potentially expect to service several destinations on a given mission, requiring more time

---

<sup>74</sup> For more information on CBR see B. K. Hough, *Basic Soils Engineering* (New York: Ronald Press, Co., 1957), 384.

in a hostile environment. Rapid onload and offload of cargo at each destination will minimize the ground time, when the aircraft potentially will be most vulnerable.

Austere and hastily prepared landing sites in the future will not have the right amounts and types of traditional materials handling equipment needed to unload the ATT [Advanced Theater Transport], and unloading operations in exposed forward sites must be accomplished quickly in order to reduce risks to the ATT, its crew, and the ground unit receiving the cargo.<sup>75</sup>

To accomplish the mission in austere locations, the airlift platform must have some level of autonomous cargo handling capability. In this case “autonomy” means accomplishing the mission without the use of external materials handling equipment. This implies the ability to drive the cargo off the aircraft, push it off, or use organic aircraft equipment to accomplish the offload. The same capabilities will be required for onload, as the future theater airlifter will be used as a maneuver element as well as a sustainment provider.

Three features of the AAN battlespace combine to increase the requirement for flexibility. These features are speed of operations, fluidity, and reduced sustainment requirements for battle forces. Fewer requirements for sustainment increase the potential for one aircraft to carry cargo for multiple destinations. The speed and fluidity of the environment can drive changes in destination priorities in flight. If such a scenario

---

<sup>75</sup> Jeffrey Record, *Determining Future U.S. Tactical Airlift Requirements* (Washington: Pergamon-Brassey's International Defense Publishers, Inc. 1987), 36.

unfolds, the airlift platform must be able to rapidly reposition cargo to allow the quickest offload at the updated destination.<sup>76</sup>

## **Situational Awareness**

The ability to operate effectively in the nonlinear battlespace of the future is of little value without the situational awareness to guide when, where, and how to adapt to the changing environment. The required capability for theater airlift directly correlates with the concept of gaining information dominance. The technologies the AAN is seeking such as advanced information processing, distribution and display will directly support the information requirements for the theater airlift platforms. The airlifters will need to be plugged into the information dominance system where “speed and quality of decision making for current and subsequent operations are the ultimate outputs.”<sup>77</sup> This helps the entire logistics system, from tooth to tail.

The Joint Total Asset Visibility (JTAV) concept currently being pursued by the Joint Staff seeks the ability to track aircraft location and status from the point of origin to the offload destination.<sup>78</sup> Real time information on equipment status will also increase flexibility for commanders in the conduct of operations. Such information will facilitate

---

<sup>76</sup> This does not suggest repositioning cargo in flight, although that proposition can not be totally ruled out. Repositioning cargo in flight has traditionally been taboo, except in emergencies. One reason is that the possibility of a “loose platform” in the cargo compartment could potentially shift the aircraft center of gravity to a point that would threaten controllability. With the advent of electronic flight controls, this danger might be mitigated. Another danger is the possibility of a “hung load” in which the aircraft acceleration in any of the three axes during repositioning can jam the load in place. This could jeopardize control during landings, and hamper onload/offload operations.

<sup>77</sup> TRADOC, *Knowledge and Speed* 1998, 24.

timely redirection of forces and combat support, allowing the AAN forces to retain initiative.

For the aircrew, being connected to the AAN information network increases responsiveness and enhances survivability. With an accurate picture of the battlespace, the crew can respond to orders to divert more effectively. Through ingress and egress threat analysis, they will have a greater capability to plan the best way to deliver the goods in a safe and timely manner.

Admittedly, the prospect of the attainability of such complete situational awareness is subject to the same caution as the AAN dependence on information dominance. The Institute for National Strategic Studies (INSS) 1998 Strategic Assessment states

Building flexibility into a software-dominated system is complex, and its ramifications can only be discovered by experience.<sup>79</sup>

If the airlift forces can achieve such situational awareness, the reward will be the luxury of conducting operations under relative certainty and a high potential for an inexpensive victory. On the other hand, if such heightened awareness eludes the airlift forces, the prospect of operating in hostile territory necessitates improved defensive capabilities to enhance survivability.

---

<sup>78</sup> Joint Chiefs of Staff, J-4, *Information Fusion*, J-4 Projects, n.d., 2: on-line, Internet, 6 March 1999, available from <http://www.dtic.mil/jcs/projects/foclog/info-fus.html>.

<sup>79</sup> Institute for National Strategic Studies, “Adaptive Forces,” *1998 Strategic Assessment: Engaging Power for Peace*, n.d., n.p.; on-line, Internet, 6 March 1999, available from <http://www.ndu.edu/inss/sa98/sa98ch15.html>.

## Defensive Systems

With the exception of special mission variants airlift platforms have, until recently, been largely devoid of defensive systems. One reason for this is that in the last half of the twentieth century, theater airlift doctrine evolved within the cold war paradigm. The role of theater airlift was to deliver the cargo from the strategic hub to destinations throughout the theater in which it was assigned. During combat operations, such lift would deliver cargo near the FLOT, but in friendly territory. Any operations beyond the FLOT would be supported by intense suppression of enemy air defenses (SEAD).<sup>80</sup> Despite the doctrine, C-130 aircrews in Vietnam were subjected to enemy fires, suffering substantial damage and demonstrating the doctrinal inadequacy for unconventional conflicts.<sup>81</sup> It was not until the “direct delivery” capability of the C-17 was promised that fleet-wide defensive systems were given significant attention. Even then, it was determined that “sustainment missions will routinely go as far forward as the brigade rear area (BRA),” 20 to 40 kilometers from the FLOT.<sup>82</sup>

The need for defensive systems for theater airlift platforms to support the AAN is self-evident. The maneuver and resupply missions will have to be flown unescorted. The notion of diverting SEAD assets from strike operations to enhance maneuver or sustainment is a violation of economy of force.<sup>83</sup> To support the AAN, theater airlift

---

<sup>80</sup> John A. Skorupa, Lt Col, USAF, *Self-Protective Measures to Enhance Airlift Operations in Hostile Environment* (Maxwell AFB, Ala.: Air University, September 1989), 33.

<sup>81</sup> Charles E. Miller, Lt Col, USAF, *Airlift Doctrine* (Maxwell AFB, Ala.: Air University, March 1988), 321-326.

<sup>82</sup> *Ibid.*

<sup>83</sup> Joint Pub 3-0, *Doctrine for Joint Operations*, 1 Feb 95, A-1.

platforms will require onboard systems to detect, avoid, and/or defeat enemy anti-air threats.

Developing defensive systems for airlift aircraft presents unique challenges. Many of the characteristics that enhance the operational airlift capability degrade aircraft survivability. The ability to deliver large quantity of troops and materiel increases the size of the cargo compartment, making the aircraft easier to spot. Larger aircraft structures also carry with them more stringent structural loading limitations, which translates into less maneuverability. Turbofan engines are used to deliver the thrust required for increased payloads and achieve fuel efficiency. These engines produce the majority of their thrust through their large fans.<sup>84</sup> These fans take time to spool up<sup>85</sup>, which also limits responsiveness and maneuverability. The challenge for the future will be to develop defensive systems that can enhance survivability without significantly degrading mission effectiveness.

Theater airlift has been an integral part of land force operations in numerous campaigns. Its use as a combat maneuver element has not been significantly tapped, and primary airborne operations have involved troop insertion and resupply. However, one particular operation in World War II had several characteristics in common with AAN

---

<sup>84</sup> C-17 engine information at “Engine Gallery – F117-PW-100,” n.d., n.p.; on-line, Internet, 10 March 1999, available from <http://pratt-whitney.com/engines/gallery/f117.html>.

<sup>85</sup> This phenomenon is quite different from turbojet engines in which advancing the throttle increases fuel flow to the combustion chamber that directly produces the engine thrust. “Spooling up” involves the time from throttle advancement to increasing fuel flow to increased energy in the combustion chamber, *and* the time it takes to translate that energy to rotating the large fan. Due to principles of momentum, this time is greatly increased at low engine power (low fan speeds).

projected operations as they relate to airlift. That effort, known as Operation Thursday, involved autonomous operations behind enemy lines and a substantial theater airlift role.

## **Operation Thursday – Burma, 1944**

Throughout 1941, Japanese ground forces had marched across much of Southeast Asia with alarming speed. The fall of Burma in the spring of 1942 bore potentially grave consequences for the Allies. Japan was threatening to isolate China from the rest of Asia and capture India, the “jewel of the British Empire.”<sup>86</sup>

The terrain in Burma was difficult, with several mountains and dense jungle. In 1943 British General Orde Wingate, aided by this terrain, planned a guerrilla warfare-style infiltration deep behind enemy lines. Resupplied by air, the infiltrating forces would disrupt or destroy enemy lines of communication and cause general disarray.<sup>87</sup> For various reasons, the campaign was only marginally successful, but it did demonstrate to the Allied leadership that “properly trained and organized groups supplied from the air, and thusly independent of normal supply lines, could operate in the jungle far behind enemy lines.”<sup>88</sup> In addition, the 1943 expedition allowed Wingate’s troops to discover clearings in the jungle that could be made suitable for airfield operations. This would be critical for the following infiltration campaign in 1944.<sup>89</sup>

---

<sup>86</sup> Herbert Mason, Randy G. Bergeron, and James A. Renfrow, *Operation Thursday, Birth of the Air Commandos* (Washington D.C.: Air Force History and Museums Program, 1994), 1.

<sup>87</sup> Lee Bowen et al, *USAF Airborne Operations: World War II and Korean War* (Washington, D.C: USAF Historical Division, 1962), 30.

<sup>88</sup> Denny Riley, “Airborne Invasion of Burma, Spring, 1944” (Master’s thesis, University of Oklahoma, 1965), 21.

<sup>89</sup> Lee Bowen et al, *USAF Airborne Operations: World War II and Korean War*, 30.

Operation Thursday, as the aerial invasion was called, was a much larger effort than its predecessor and relied heavily on airlift for troop insertion and substantial aerial resupply. Initial forces were carried in gliders towed by C-47 aircraft, and arrived at the designated airfield locations to prepare the areas for takeoff and landing operations. Though problems such as towing rope failures, unexpected turbulence enroute, and unexpectedly harsh landing conditions degraded mission effectiveness, the results of the initial insertion were unprecedented.

All told, 539 men, 3 animals, and 65,972 pounds of stores had been safely put down, including such heavy items as bulldozers and lighting apparatus, and within twenty-four hours an airstrip, 300 by 5,000 feet, was cleared and prepared.<sup>90</sup>

Operation Thursday lasted from 5 March to 17 May, 1944, although a heavy sustainment effort continued for an additional four months.<sup>91</sup> The overall strategic success of the infiltration is subject to debate, but the impact of the four airlift capabilities developed in this chapter were apparent in the operation.

*Austere Operations.* Operation Thursday taught a painful lesson on the importance of surveying a prospective austere site for aircraft suitability. The relatively inviting appearance of a grassy surface hid the dangers of the water buffalo holes beneath them. This uneven surface claimed the landing gear of the initial arriving gliders. This resulted

---

<sup>90</sup> Wesley Craven and James Cate, *Army Air Forces in World War II*. Vol. 4, *The Pacific: Guadalcanal to Saipan, August 1942 to July 1944* (1949; new imprint, Washington, D.C.: Office of Air Force History, 1983), 505.

<sup>91</sup> Lee Bowen et al, 38.

in the inability to clear the landing zone, causing subsequent gliders to crash into the immobile hulks.<sup>92</sup>

Once cleared and prepared, the austere airfields provided distinct advantages over airdrop resupply operations. One of great importance was the ability to evacuate casualties from the area. The C-47 aircraft evacuated 914 casualties during the month of April.<sup>93</sup> This greatly increased combat effectiveness and morale when compared to Wingate's first expedition in which "about 30 percent of the original force were casualties; most of the wounded and exhausted were of necessity left behind."<sup>94</sup> Cargo delivery by landing was also much more efficient than airdrop.

Transports could carry a heavier load for dropping than for landing, but parachutes and packing weighed more than enough to offset the increase in gross load...Over a period of more than a few days airdrop delivery could not be maintained at the same rate as delivery by landing.<sup>95</sup>

*Cargo Handling Capability.* In the ten weeks in support of Operation Thursday, the C-47 transports flew over 1,000 sorties, hauling some 13,000 troops, 2,000 mules, and 528 tons of supplies throughout Burma.<sup>96</sup> This demanded substantial cargo handling efficiency. In fact, at the main forward operating location, known as Broadway, the

---

<sup>92</sup> Joe Taylor, *Air Supply in the Burma Campaign* (Maxwell AFB, Ala: USAF Historical Division, Research Studies Institute, Air University, 1957) 68.

<sup>93</sup> Ibid., 72.

<sup>94</sup> Ibid., 14.

<sup>95</sup> Ibid., 137.

<sup>96</sup> Lee Bowen et al, *USAF Airborne Operations: World War II and Korean War*, 40.

average total time on the ground was twenty minutes.<sup>97</sup> Even though the average load was only 4,750 pounds, that was still an impressive aircraft turn time.<sup>98</sup>

One specific challenge was the requirement to haul mules, as they were the prime means of moving heavy equipment on the ground. This challenge was answered by the construction of bamboo stalls in the cargo compartments of the C-47s. Muleteers accompanied the mules on transport flight and trained them on walking up the cargo ramp to improve efficiency and speed in loading operations.<sup>99</sup>

**Figure 2. Offloading the “Prime Mover” from a C-47**



Source: *Joint Forces Quarterly*, Summer 1996, 102.

---

<sup>97</sup> Riley, “Airborne Invasion of Burma, Spring, 1944,” 75.

<sup>98</sup> Ibid., 74.

<sup>99</sup> Ibid., 95.

*Situational Awareness.* The tactics of night operations brought with them an inherent loss of situational awareness. If operations would have been conducted during daylight, the obstacles encountered by the initial gliders might have been avoided, enabling the ground mobility required to prepare for the second wave. Several airdrop missions were also unsuccessful because the drop zones were difficult to distinguish at night and the ground forces were not enthusiastic about lighting signal fires that would attract snipers.<sup>100</sup>

One example of “just in time intelligence” that increased situational awareness occurred just before the launch of the initial gliders. An Air Commando photographic officer had flown over a second prospective site named Piccadilly. The photographs (taken without consent of Wingate, wanting to preserve operational security) revealed that large trees had been dragged across the landing zone, rendering it unusable.<sup>101</sup> This timely information led to the abandonment of Piccadilly as a forward airfield, and might have spared significant casualties.

*Defensive Systems.* One of the reasons the transports flew at night was because of lack of fighter escort. This tactic proved very successful, with only one C-47 seriously damaged throughout the resupply operations.<sup>102</sup> Another factor contributing to aircraft survivability was that the operations were conducted deep behind enemy lines, and the majority of the Japanese fighters were focusing on the skies near the main effort. A somewhat obvious observation, but one that will have significant implications for future

---

<sup>100</sup> Ibid., 92.

<sup>101</sup> Craven and Cate, *Army Air Forces in World War II*. Vol. 4, *The Pacific: Guadalcanal to Saipan, August 1942 to July 1944*, 505.

<sup>102</sup> Taylor, *Air Supply in the Burma Campaign*, 72.

Army After Next airlift support, was that the majority of the damage inflicted on the transports came from small arms and automatic weapons fire around the airfields and drop zones.<sup>103</sup>

The airlift operations in support of Operation Thursday provide several lessons for future employment in hostile environments. However, it is important not to take too much from history. The primary airlift missions in Burma were insertion and resupply. These will be important in future conflicts, but the role will be expanded to include providing mobility for substantial battle forces and equipment. This will require learning from history as well as innovative forward thinking.

In summary, the AAN will place unprecedented challenges for theater airlift systems. The logistic principles of *flexibility* and *survivability* will become more important, and the next generation airlift system must be designed with these principles in mind. To deliver on this requirement, future theater airlift platforms must maximize four capabilities of increasing importance in the 21<sup>st</sup> century battlespace: 1) austere operations 2) cargo handling capability, 3) situational awareness, and 4) defensive systems. As the following chapter will illustrate, there is often a difference between the world as we wish it and the world as it really exists.

---

<sup>103</sup> Ibid., 138.

## Chapter 4

### Current Theater Airlift Capabilities

*Every tool carries with it the spirit by which it has been created.*

—Werner Karl Heisenberg

Given the capability requirements for future theater airlift derived in this paper, it is useful here to identify the capabilities and growth potential of current systems. Such an analysis will illuminate capability gaps and pave the way for assessing future concepts to support the Army After Next. To keep the discussion relevant to the central argument, this chapter will evaluate current systems against the criteria of *austere operations, cargo handling capability, situational awareness, and defensive systems.*

Today's Air Force airlift fleet consists of the C-5, C-17, C-141, KC-10, KC-135, and C-130 aircraft. The capability analysis in this section will be limited to the C-130 and C-17 aircraft. The C-5, KC-10, and KC-135 are excluded because they support the strategic lift requirements. The C-141 conducts theater operations to include aerial delivery, but is not included in this analysis because it is scheduled for retirement by 2006, long before the AAN concept is realized.<sup>104</sup> The performance differences between the C-130E/H and the C-130J variant are significant enough to warrant a separate analysis. The analysis

---

<sup>104</sup> Gen Charles T. Robertson, Jr., "Keynote Address to the Airlift/Tanker Association," 24 October 1998, n.p.; on-line, Internet, 6 March 1999, available from [http://public.scott.af.mil/hqamc/speeches/ata\\_98.htm](http://public.scott.af.mil/hqamc/speeches/ata_98.htm).

will also include the CH-47 and the V-22, two non-Air Force platforms with substantial lift capability. Table 1 presents a summary of the capabilities evaluation.

**Table 1. Current Theater Airlift Platform Capabilities**

A/ C Ty pe	Austere Operations				Cargo Handling	Situatio nal Awareness	Defen sive Systems
	Runway required (ft)* on prepared/unprepared surface		Oth er				
	20, 000	39, 000	100, 000				
C1 30 E/ H	175 0/ 210 0	265 0/ 265 0	N/A	GP S retrofit in prog	6 pallets, ext MHE required	GPS retro, 5 person crew	Radar warn & CM, IRCM
C1 30J (J- 30)	140 0/ 170 0	240 0/ 240 0	N/A	HU D, GP S	6 (8) pallet ext MHE required, ECHS	GPS, HUD, dig. moving map, glass cockpit	Radar warn & CM, IRCM
C- 17	156 0/ 164 0	178 0/ 189 0	2490 / 2800	HU D, GPS	18 pallets, outsized cargo, ext	GPS, HUD, glass cockpit, AFMSS	Radar warn, IRCM

					MHE req'd		
C H-47	N/ A	N/ A	N/A	V/T OL	14K int capacity, 26k ext (not sim- ultaneous)	databus upgrade possible	Radar warn & CM, IRCM, 3 gun mounts
V- 22	N/ A	N/ A	N/A	V/T OL GP S	20k int capacity, 15k ext (not sim- ultaneous)	GPS, HUD, glass cockpit, FLIR	Radar warn & CM, IRCM NBC prot, gun mounts

\*Note: Runway required data are based on the more restrictive between takeoff and landing ground

roll. In operations, takeoff distance is increased by the requirement to clear a fifty-foot obstacle, but for comparative integrity with the ATT contractors' runway performance, ground roll is used here. Also note that on the C-130E/H and –J data, the data are the same for prepared and unprepared at the heavier weights. This is because the C-130 performance manuals compute the degradation on semi-prepared runways as a function of runway condition reporting (RCR) numbers, which do not affect takeoff roll. C-17 numbers are based on actual and modeled data with respect to increased rolling friction at degraded runways. This affects takeoff roll, and the C-17 numbers reflect this.

## C-130E/H

First rolling off the assembly line in 1961, 390 C-130E aircraft were produced for the U.S. Air Force. Twelve years later, the improved C-130H took its place, and 315 of these models were produced before the assembly line closed in late 1996.<sup>105</sup> The primary

---

<sup>105</sup> Paul Jackson, ed, *Jane's All the World's Aircraft 1997-98* (Alexandria, VA.: Jane's Information Group, Inc, 1997), 652.

change with the “H” model came in the form of more powerful engines, increasing the cruise speed from 280 to 300 knots. The better power plant increases takeoff and landing performance, and these will be used to represent the C-130E/H “family.”

## Austere Operations

The C-130E/H can operate with payloads of 25,000 pounds through runways as short as 1,750 feet.<sup>106</sup><sup>107</sup> Increasing to the maximum payload of 39,000 pounds increases the runway requirement to 2,650 feet. The aircraft does have the capability for operations on semi-prepared surfaces, but this increases the runway requirements even further, to 2,100 feet and 2,650 feet for the respective loads.<sup>108</sup> The C-130E/H can airdrop up to sixty-four paratroopers, as well as equipment ranging from container delivery system (CDS) bundles to heavy platforms such as the 42,000 pound Sheridan Light Armored Vehicle<sup>109</sup>. This aircraft can also perform precision aerial delivery through the Low Altitude Parachute Extraction System (LAPES).<sup>110</sup> In Vietnam, this capability was very useful for the sustainment of Khe Sanh after the 1968 Tet Offensive.<sup>111</sup>

---

<sup>106</sup> Payload weights for evaluation were chosen to represent a mid-range capability and one for maximum weight operations. To retain operational relevance, calculations were made factoring in sufficient fuel onboard for two hours of flight plus required reserves.

<sup>107</sup> Robins Air Logistics Center, *T.O. 1C-130H-1-1, C-130H Performance Manual*, May 1986, 3-56.

<sup>108</sup> *Ibid.*, 9-19.

<sup>109</sup> Jackson, *Jane’s All the World’s Aircraft 1997-98*, 653.

<sup>110</sup> For a description of LAPES operations, see: Maj Michael P. Davis, “Low Altitude Parachute Extraction System Approach to Extraction Zone Procedures” (Scott AFB, IL: Air Mobility Command, June 1993), 1.

<sup>111</sup> Interview conducted with Dr. Dave Mets (Lt Col (ret)) 10 March 1999. Dr Mets was a C-130B and later a Gunship pilot during Vietnam and conducted LAPES operations into Khe Sanh.

## Cargo Handling Capability

The C-130E/H can carry up to six standard 463L logistics pallets (five for airdrop since the ramp pallet position at the rear of the aircraft is unavailable for drop operations), and conducts loading through the tail of the aircraft.<sup>112</sup> It requires the same materials handling equipment of its strategic brethren. Forklifts and “K” loaders (so named for their cargo weight capacity, e.g. 40”K” for 40,000 pound capacity) handle the palletized cargo. The C-130 possesses a combat offload capability for palletized cargo. The procedure consists of releasing the restraint devices and locks on the load, accelerating, and allowing the aircraft to advance and the cargo to roll off onto the ramp. This procedure is available for palletized cargo up to 15,000 pounds.<sup>113</sup>

## Situational Awareness

Current flight instrumentation is relatively primitive by today’s standards. Currently, the navigation system on most aircraft does not integrate with the global positioning system (GPS), relying partially on inertial navigation systems for guidance. The radar is suitable for weather mapping and limited identification of major geographic features. The aircraft systems require a flight engineer for operation and monitoring. Most operations require a five-person crew.<sup>114</sup>

---

<sup>112</sup> Jackson, *Jane’s All the World’s Aircraft* 1997-98, 653.

<sup>113</sup> Multi-Command Regulation 55-130, Vol II, *Official Title*, 1 Aug 1993, 31.

<sup>114</sup> Multi-Command Regulation 55-130, Vol I, *Official Title*, 15 April 1993, 8.

## Defensive Systems

The defensive systems on many of the aircraft consist of the AAN/AR Missile Warning System to detect both radar and infrared threats.<sup>115</sup> In addition, the aircraft are equipped with countermeasures in the form of chaff, flares, and the ability to carry electronic countermeasure (ECM) jamming pods.<sup>116</sup> The C-130 is also equipped with armor-protected seats. Flak curtains are also available for placement in the lower forward windows.

## Growth Potential

The major areas Air Mobility Command is pursuing with the C-130E/H fleet reside in the areas of situational awareness and defensive systems. Currently, there are retrofit operations underway to integrate GPS into the navigational systems.<sup>117</sup> This will not only aid the crew in situational awareness, but will improve airdrop accuracy at austere locations. Defensive systems are being improved by the installation of the ALR-69 Radar Warning Receiver which will provide a more robust threat identification.<sup>118</sup> These retrofit operations will support a very elaborate project being undertaken by AMC to bring all the C-130 aircraft prior to the “J” model to a single standard. This project has

---

<sup>115</sup> Robins Air Logistics Center, *T.O. 1C-130H-1, C-130H Operations Manual*, October 1998, 4-287.

<sup>116</sup> Ibid., 4-357, 4-359.

<sup>117</sup> Air Mobility Command, “Combat Operations” 1998 *Air Mobility Master Plan Update*, n.d., n.p.; on-line, Internet, 10 March 1999, available from [http://public.scott.af.mil/hqamc/about/ammp/EQUIPMNT/8\\_AMCwep/4\\_C\\_130.htm](http://public.scott.af.mil/hqamc/about/ammp/EQUIPMNT/8_AMCwep/4_C_130.htm).

<sup>118</sup> Ibid.

backing from the highest levels, as indicated in the following passage from General Robertson, Commander in Chief, Air Mobility Command.

*I say again: we're going to create a single model out of the mix: an aircraft we call the C-130X. The modifications will run the gamut, from electrical system upgrades to glass cockpits with flight management systems and NVG lighting upgrades...to, in the final phase of our three phase plan, a common engine, APU, and any structural repairs required.*<sup>119</sup> (emphasis in the original)

### **C-130J (and J-30)**

The introduction of the C-130J into the fleet represents a leap ahead in technology far greater than any obtained by its predecessors. In fact, the changes in propulsion, avionics, and cargo handling that much of its operational support will require training and logistics infrastructure separate from the rest of the C-130 fleet.<sup>120</sup> To avoid redundancy, this section will only elaborate on the changes from the current C-130 fleet that impact the evaluation criteria. The C-130J-30 is a “stretch” version, with fifteen feet added to the fuselage.<sup>121</sup> For the purpose of this analysis, the capabilities of the C-130J-30 are the same as the smaller version unless stated otherwise.

---

<sup>119</sup> Gen Charles T. Robertson, Jr., “Keynote Address to the Airlift/Tanker Association,” 24 October 1998, n.p.; on-line, Internet, 6 March 1999, available from [http://public.scott.af.mil/hqamc/speeches/ata\\_98.htm](http://public.scott.af.mil/hqamc/speeches/ata_98.htm).

<sup>120</sup> United States General Accounting Office. “Intratheater Airlift: Information on the Air Force’s C-130 Aircraft: report to the Honorable John McCain, U. S. Senate” (Washington, D.C.: USGAO, 1998), 11.

<sup>121</sup> Jackson, *Jane’s All the World’s Aircraft 1997-98*, 652.

## Austere Operations

The more powerful, electronically controlled engines and more efficient propellers combine to significantly improve takeoff and landing performance. This increase in thrust at low speed brought with it the potential for controllability problems in the event of an engine failure. This was overcome by the development of an automatic system that integrates the electronic engine control with aircraft control parameters to provide increased performance and controllability.<sup>122</sup> On a prepared surface, operating with cargo weights of 25,000 and 39,000 pounds requires runway lengths of 1,400 and 2,400 feet respectively. Similar operations on unprepared surfaces will require 1,700 and 2,400 feet.<sup>123</sup> The enhanced cargo handling system interfaces with the onboard computer to provide a more accurate airdrop capability.<sup>124</sup>

Another performance enhancing system that will aid in austere operations is the Head Up Display (HUD). This system provides the capability to control aircraft performance and navigate while retaining the ability to scan the horizon. More important for austere operations, however, is the ability to establish a visual approach path without the aid of external navigation aids. By maneuvering the aircraft to overlay the desired

---

<sup>122</sup> Lyle H. Schaeffer, "Automatic VMC Protection in the C-130J," *Society of Experimental Test Pilots Forty-First Symposium Proceedings*, (Lancaster, CA.: Society of Experimental Test Pilots, 1997), 235-252.

<sup>123</sup> The C-130J performance data is still being developed. Numbers for prepared surface are based on performance specification requirements in *Lockheed C-130J Manufacturer Model Specification, Document No. ER/S-7100M/J-0.Revision E, 28 Aug 96*. Semi-prepared runway data estimated based on RCR calculation used on C-130E/H.

<sup>124</sup> Enhanced Cargo Handling System still in development for USAF. I attended several design/integration meetings as the Air Force test pilot representative between Nov 96 – May 97. For more information, contact the C-130J Test Team, 418<sup>th</sup> Flight Test Squadron, Edwards AFB, CA.

glide path parameters on the appropriate aimpoint, aircrews can perform more accurate landings and avoid wasting valuable landing surface.

## **Cargo Handling Capability**

The enhanced cargo handling system aids the loadmaster in cargo loading operations. The automatic locking devices and system status monitoring capability provide information essential for rapid and efficient operations. The floor is redesigned to allow rapid configuration changes for palletized cargo or rolling stock. The C-130J-30 has two additional pallet positions for carrying cargo, but its increased structural weight actually decreases the payload capacity by 2,400 pounds.<sup>125</sup>

## **Situational Awareness**

The C-130J is equipped with a state of the art avionics suite. The navigation system contains an embedded GPS capability and a digital autopilot. The HUD will also greatly aid in situational awareness, allowing the crew to monitor performance and flight progress while retaining the ability to scan their surroundings. The Northrop Grumman AN/APN low power color radar is capable of supporting digital moving map imagery.<sup>126</sup> This translates into a capability to present known or suspected surface-to-air threats, overlay navigation information, and adjust ingress and egress routes in hostile areas.

The potential does exist for the C-130J to *decrease* situational awareness from the earlier versions. The C-130J crew complement will be reduced from the previous aircraft

---

<sup>125</sup> United States General Accounting Office, “Intratheater Airlift,” 19.

<sup>126</sup> Jackson, *Jane’s All the World’s Aircraft* 1997-98, 656.

by forty percent. Automation can perform several tasks formerly done by crewmembers, but in a high workload environment, task saturation is an issue worth considering.

## **Defensive Systems**

The C-130J models will enter service with all of the defensive systems described for the C-130E/H. The only real advantage these newer systems will possess is a deeper integration into the overall system. The situational awareness advances previously discussed will enhance the effectiveness of the defensive systems by offering the potential to avoid their use through threat avoidance.

## **C-17**

The C-17 is the most capable airlift aircraft developed to date. Technological advances in flight control systems and structural design provide the aircraft with the capability to accomplish both the inter- and intratheater airlift mission very effectively.

## **Austere Operations**

One of the main design features that gives the C-17 the capability to operate at high gross weights into small airfields is known as “blown lift.” This concept involves positioning high lift devices such as flaps in such a manner that jet thrust is applied to them at low speeds, offsetting the reduction in airflow across the wing.<sup>127</sup> The C-17 can deliver the 25,000 and 39,000 pound loads into a paved surface of 1,560 and 1,780 feet,

---

<sup>127</sup> For more information on the “blown lift” concept, see W.H. Deckert and J.A. Franklin. *Powered-Lift Aircraft Technology* (Washington, D.C.: Scientific and Technical Information Division, National Aeronautics and Space Administration, 1989), 5.

respectively.<sup>128</sup> Delivering the same cargo into unprepared surfaces requires 1,640 and 1,900 feet.<sup>129</sup> The C-17 has the ability to deliver significantly more cargo than its C-130 counterpart. For example, it can deliver equipment such as the fifty ton M60 tank into prepared airfields as small as 2,490 feet and unprepared surfaces of 2,800 feet.<sup>130</sup> As with the C-130J, the HUD in the C-17 greatly aids in precision landings to airfields with no navigational aids. The C-17 has a robust airdrop capability, able to deliver up to 102 paratroopers. The C-17 can also airdrop single platforms of 60,000 pounds, and deliver a total of 110,000 pounds of equipment on a single pass across the drop zone.<sup>131</sup>

## **Cargo Handling Capability**

The wide body of the C-17 accommodates outsized cargo and can carry two rows of palletized cargo. Loading operations are conducted solely through the aft end of the cargo compartment. The cargo floor does not possess the capability to shift palletized cargo laterally. The automation in the cargo compartment greatly reduces loadmaster workload. Standard external materials handling equipment of forklifts and “K” loaders are required for palletized cargo operations. Traditional methods of tying down cargo

---

<sup>128</sup> Data computed from C-17A Mission Computer Block 10, #P601H. Also see Wright-Patterson AFB, *TO 1C-17A-1-1, Performance Manual*, 15 August 95, Change 8, 1 September 98.

<sup>129</sup> Ibid., For more information on C-17 unpaved runway testing, see Peter Bouras and Maj Pamela A. Melroy, “C-17A Unpaved and Matted Runway Operations,” Report no. AFFTC-TR-95-22 (Edwards AFB, Calif.: Air Force Flight Test Center, October 1995), 13, 21.

<sup>130</sup> Ibid., also Wright-Patterson AFB, *TO 1C-17A-1-1, Performance Manual*, 15 August 95, Change 8, 1 September 98, 342.

<sup>131</sup> SSgt Scott M Bailey, “60,000 Pound (60K) Linked and 110,000 Pound (110K) Sequential Platform Low Velocity Airdrop (LVAD): Follow-on Operational Test and Evaluation (FOT&E) of the C-17 Aircraft,” (Fort Dix, N.J.: Air Mobility Command, Air Mobility Warfare Center, 33d Flight Test Squadron, 1998), v.

with fore and aft restraints are still required in the C-17. Combat offload procedures similar to those described for the C-130 permit the offload of 85,000 pounds of cargo in less than 450 feet.<sup>132</sup>

## **Situational Awareness**

The C-17 is equipped with state of the art avionics, including GPS- aided navigation, glass cockpit design, and onboard computers that aid in mission planning and operations. Improved mission planning systems such as the Air Force Mission Scheduling System (AFMSS) provide aircrews the opportunity to preplan a mission on a personal computer, include pertinent data specific to their mission and upload it for display.<sup>133</sup> Though the system does not provide real time updates, display information such as projected surface-to-air threats will enhance situational awareness.

## **Defensive Systems**

The C-17 defensive suite is not as robust as its C-130 counterpart. It does possess the AAR-47 Missile Warning System (MWS) and the ALE-47 Countermeasures Dispense Set (CMDS) to respond to infrared missile threats.<sup>134</sup> These systems do not respond to radar threats. Logic dictates that the development of a system to counter radar threats is likely untenable, given the size of the C-17 radar cross section. Each crew

---

<sup>132</sup> Michael J. Kamosa and Michael J. Welch, “Evaluation of C-17 Combat Offload Capabilities,” Report no. AFFTC-TR-94-24 (Edwards AFB, Calif.: Air Force Flight Test Center, October 1995), 15.

<sup>133</sup> US Air Force Air Mobility Command, *1997 Air Mobility Master Plan* (Scott AFB, IL: Air Mobility Command, October 1996), 5-68.

<sup>134</sup> Capt Jeffrey E. Gates, “C-17 Defensive System (DS) 1553B Bus Interface: Combined Developmental/Operational Test and Evaluation (D/OT&E), Detailed Test Plan,”

position is provided armor protection against ordnance up to 12.7m armor piercing incendiary rounds.<sup>135</sup>

## **CH-47D**

This tandem rotor CH-47 transport helicopter aircraft rivals the C-130 in its longevity, making its maiden test flight in 1961.<sup>136</sup> The CH-47D represents the newest and most capable variant. First delivered in 1981, 481 of the helicopters were built.<sup>137</sup>

### **Austere Operations**

As with any VTOL aircraft, the airfield requirements for the CH-47D are minimal. For landing, the distance required is slightly longer than the 99-foot aircraft length to allow for clearance.<sup>138</sup> Because of its capacity for external carriage, some operations may be done from a hover, and require less surface. The absence of a landing roll requirement also increases the options available for landing, as the consequences of touching down on uneven ground are much less catastrophic.

### **Cargo Handling Capability**

Three hooks mounted on the belly of the CH-47 provide the capability to lift up to 26,000 pounds externally. Internally, the maximum carrying capacity is 14,000

---

T/WR 98-02 (Fort Dix, N.J.: Air Mobility Command, Air Mobility Warfare Center, 33d Flight Test Squadron, 1998), v.

<sup>135</sup> Rodney L. Cleary, and Franklin L. Spear III. “C-17 Crew Armor Protection.” Report no. T/WR 96-02. (Fort Dix, N.J.: Air Mobility Command, Air Mobility Warfare Center, 33d Flight Test Squadron, 1997), v.

<sup>136</sup> Jackson, *Jane's All the World's Aircraft 1997-98*, 583.

<sup>137</sup> *Ibid.*, 584.

pounds<sup>139</sup>, including up to fifty troops (thirty-three fully equipped) or two High Mobility Multipurpose Wheeled Vehicles (HMMWV).<sup>140</sup> The Army is also considering upgrades to the cargo floor, allowing rapid reconfiguration for different load types.<sup>141</sup>

## **Situational Awareness**

The avionics suite is basic, with dual displays and flight directors. The Army is considering a proposal for an avionics upgrade to include a digital cockpit and a central databus. This will facilitate “updated communications and navigation, enabling the Chinook to meet U.S. Army Force XXI Battlefield requirements.”<sup>142</sup>

## **Defensive Systems**

Having been designed to operate very near hostile fire, the CH-47 contains a robust defensive suite. As with the previous aircraft, it contains the AAN-47 Missile Warning System, as well as chaff and flare dispensers and jamming equipment. In addition, the helicopter contains provisions for three machine guns or miniguns.<sup>143</sup> This offensive capability provides an increased deterrent and enhances survivability.

---

<sup>138</sup> “Aerospace Source Book: Rotary-Wing Outlook/Specifications,” *Aviation Week & Space Technology*, 11 January 1999, 78.

<sup>139</sup> Jackson, *Jane’s All the World’s Aircraft 1997-98*, 587.

<sup>140</sup> “Army Technology – CH-47D/MH-47E Chinook – Heavy Lift Helicopter,” n.d., n.p.; on-line, Internet, 11 March 1999, available from <http://www.army-technology.com/projects/chinook/index.html>.

<sup>141</sup> Jackson, *Jane’s All the World’s Aircraft 1997-98*, 585.

<sup>142</sup> *Ibid.*

<sup>143</sup> *Ibid.*, 588.

## V-22

The V-22 Osprey represents a great technological accomplishment. Its tilt rotor design provides the combination of both speed and VTOL. Having waded through funding cutbacks and technical challenges since its full-scale development initiation in 1986, the V-22 is scheduled for initial operational capability (IOC) in 1999.<sup>144</sup>

### Austere Operations

The V-22 enjoys the same advantages as the CH-47 in this area. The surface area required is marginally smaller, needing only to accommodate the eighty-four foot aircraft width.<sup>145</sup> As with the CH-47, hover operations will potentially reduce this requirement further.

### Cargo Handling Capability

The maximum internal payload for the V-22 is 20,000 pounds, while external capacity is limited to 15,000 pounds.<sup>146</sup> The cabin can carry twenty-four troops, and the cargo floor is equipped with rollers to handle palletized cargo and a winch with a 2,000 pound pulling capacity.<sup>147</sup>

---

<sup>144</sup> Director, Operational Test and Evaluation, Office of the Secretary of Defense. *V-22 Osprey FY97 Annual Report*, n.d., 2; on-line, Internet, 10 March 1999, available from <http://dote.osd.mil/reports/FY97/navy/97mv22.html>.

<sup>145</sup> Jackson, *Jane's All the World's Aircraft 1997-98*, 580.

<sup>146</sup> *Ibid.*

<sup>147</sup> "Air Force Technology – V-22 Osprey –Medium Lift Multi-mission Tilt Rotor Aircraft," n.d., n.p.; on-line, Internet, 11 March 1999, available from <http://www.airforce-technology.com/projects/osprey/index.html>.

## **Situational Awareness**

The avionics suite is state of the art, with GPS-aided navigation systems and onboard mission computers. In addition, the navigation displays have the ability to overlay a digital moving map images.<sup>148</sup> The digital map is presented through an integration of a geographic database and the GPS to provide information on terrain features and potential threats. A forward-looking infrared radar (FLIR) is also available for navigation during low visibility.<sup>149</sup>

## **Defensive Systems**

The V-22 carries the AN/AAR-47 Missile Warning System, along with chaff and flares. Additional defensive features include provisions for nose and gun mounts and self-sealing fuel tanks. The V-22 is the only aircraft in this analysis designed with an air-filtered cockpit to protect from nuclear, biological, and chemical (NBC) threats.<sup>150</sup>

## **Coming Up Short**

Each aircraft described in this chapter possesses some satisfactory capabilities for integration into the Army After Next. The C-130 offers a robust defensive suite and the ability to deliver medium cargo loads into relatively small fields. The C-130J retains all of the characteristics of its older counterpart, and adds value in the areas of runway performance, situational awareness, and marginally in cargo handling.

---

<sup>148</sup> Jackson, *Jane's All the World's Aircraft 1997-98*, 580.

<sup>149</sup> Ibid

<sup>150</sup> "Air Force Technology – V-22 Osprey –Medium Lift Multi-mission Tilt Rotor Aircraft," n.d., n.p.; on-line, Internet, 11 March 1999, available from <http://www.airforce-technology.com/projects/osprey/index.html>.

The C-17 offers a leap in performance, cargo weight, and cargo type with the addition of outsized cargo and battle tank capacity. The desire for a transport that could fulfill both the strategic and tactical mission increased the size of the C-17. In the tactical airlift role, this resulted in an airplane with a reduced defensive capability when compared to the C-130 models.

The VTOL aircraft provide exceptional austere operations capability, but this comes at the cost of payload capacity. Though not analyzed within the capability criteria, the increased reach available with the V-22 tilt rotor technology represents a leap in flexibility over the medium lift assets it will replace.

When all is said and done, the capabilities that exist within today's theater airlift force are inadequate to support the Army After Next vision. None can meet the SSTOL/payload requirement. At this point, only the C-17 has the cargo capacity to carry the fighting vehicles. The extensive cargo handling equipment required to process cargo is too cumbersome to facilitate minimum ground times at austere locations. Situational awareness aids do not provide a current picture of the environment, and crews are reliant on radio communications for updates.

In general, the trend toward the required capabilities of the twenty-first century airlifter appears healthy. The C-17 demonstrates the technological leap fitting of its relative operational infancy. The biggest detriment to a greater advance by the C-130J is the fact that it is trapped in the body of a forty-five year old aircraft design. The V-22 brings a tremendous capability to its niche mission. That niche mission does not support the AAN vision as it relates to operational maneuver and sustainment.

The area that has perhaps benefited the most from recent technology is situational awareness. Upgrades in navigational accuracy, Head Up Displays, mission computers, and cockpit displays producing imagery from massive databases provide the crew with timely information. Conversely, defensive systems for cargo aircraft have advanced relatively slowly, despite technological advances. Perhaps this is because in the cost-benefit analysis, the very size and characteristics of a cargo aircraft drive its design to something that is a relatively easy target. That size and relative lack of maneuverability also make the rudimentary countermeasures relatively easy to defeat from the air.<sup>151</sup>

As the caretaker of the USAF airlift fleet, Air Mobility Command is currently taking steps toward realizing some of the future capabilities identified in this paper. Each year, AMC provides an updated Air Mobility Master Plan (AMMP) that provides information on vision and strategy to support future requirements. One capability being pursued is real time information in the cockpit (RTIC).

The RTIC is a situational awareness capability to receive, process and display real-time and near real-time information overlaid on photos and charts. The technology includes flight following, two and three-dimensional threat displays, terrain perspective views, and mission rehearsal.<sup>152</sup>

The technology for RTIC has been in existence for several years, and is being designed into the F-22. Such a system on airlift platforms will provide the architecture required for integration and display of the Army After Next battlespace picture.

---

<sup>151</sup> Interview with Major Tom Bergeson, 12 Mar 99. Major Bergeson is an F-15C pilot, a graduate and former instructor at the USAF Fighter Weapons School.

<sup>152</sup> US Air Force Air Mobility Command, *1997 Air Mobility Master Plan* (Scott AFB, IL: Air Mobility Command, October 1996), 5-67.

The AMMP also addresses modernizing materials handling equipment. These improvements are in the form of upgrade and standardization of the current “K” loader fleet. Though such advances are limited by the configurations and offload capabilities of the current platforms, the AMMP concedes that “changes in user profiles, aircraft configurations, and expected operating parameters will likely make it necessary to identify and procure follow-on and replacements for all loader types.”<sup>153</sup> Defensive systems initiatives are limited to the fleet-wide upgrade to the more advanced AL-69 Radar Warning Receiver and retrofit of any applicable aircraft with chaff and flare capability.<sup>154</sup>

Between the existing capabilities and the proposed improvements, Air Mobility Command is providing a theater airlift system as robust as the airframes will allow. It is important to remember that the four desired capabilities identified for analysis were chosen because they support the increasingly important logistics principles of *flexibility* and *survivability*. Though the current system supports these principles in today’s environment, the operational concept for theater lift to support the AAN expands both principles’ scope.

Flexibility will include the capability to operate at several locations throughout the battlespace. Current runway requirements and the need for significant external cargo handling equipment inhibit such flexibility. Survivability on the ground will become a greater concern in supporting AAN operations, as the onload/offload mission will presumably be conducted in hostile areas. Current cargo handling systems are not

---

<sup>153</sup> Ibid., 5-71.

responsive enough to enhance survivability on the ground. The situational awareness enhancement of a real time in the cockpit (RTIC) system is the one capability that in and of itself will accommodate both flexibility and survivability, perhaps making it the greatest current theater airlift contribution to the AAN vision.

There is clearly a gap between the Army After Next concept and the theater airlift system to support it. One need look no further than the Training and Doctrine Command (TRADOC) Pamphlet 525-66, *Future Operational Capability* to see several glaring shortfalls.<sup>154</sup> To enhance the future joint warfighting effort the theater airlift force must develop its capabilities with the support of the AAN in mind. It is time to bridge the gap.

---

<sup>154</sup> US Air Force Air Mobility Command, “Operations,” *1998 Air Mobility Master Plan Update*, n.d., n.p.; on-line, Internet, 10 March 1999, available from [http://public.scott.af.mil/hqamc/about/ammp/ROADMAPS/24\\_ds.htm](http://public.scott.af.mil/hqamc/about/ammp/ROADMAPS/24_ds.htm).

<sup>155</sup> TRADOC, Pamphlet 525-66, *Future Operational Capability* “TC 97-004, Super Short Takeoff and Landing (SSTOL),” “TC 97-001, Logistics Mobility,” “TC 97-002, Resupply,” “AV 97-009, Improved Aircraft Performance,” “TR 97-032, Sustainment Logistics Support,” n.d., n.p.; on-line, Internet, 6 March 1999, available from <http://www-tradoc.army.mil/tpubs/pams/p525-66e.htm>.

## Chapter 5

### Bridging the Gap – Future Theater Airlift Concepts

*Any sufficiently advanced technology is indistinguishable from magic.*

—Arthur C. Clarke

Identification of capability deficiencies contains little utility if not accompanied by alternatives on how to rectify them. This chapter will present several concepts that attempt to provide satisfactory alternatives. Two concepts in direct competition with each other are the Advanced Theater Transport (ATT) aircraft designs of Boeing and Lockheed. Other concepts described may be complementary to one of these designs, both, or neither. Because of the diversity in the breadth and extent that each concept supports the AAN, the alternatives will be categorized under the four previously identified capabilities of austere operations, cargo handling capability, situational awareness, and defensive systems.

#### Austere Operations

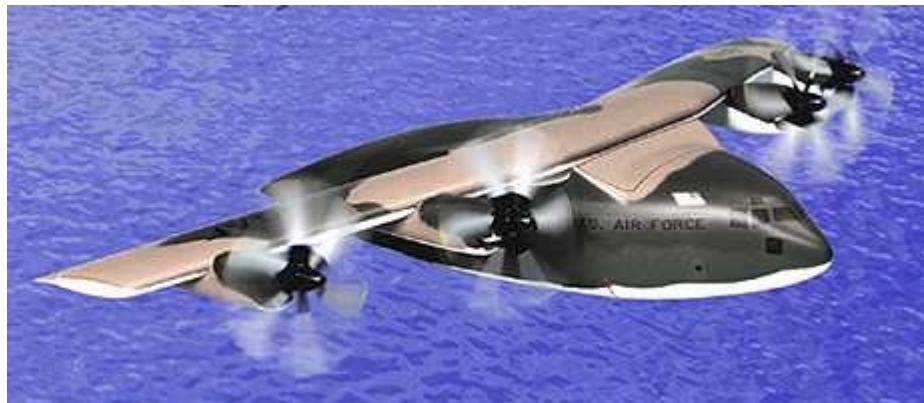
##### Super Short Takeoff and Landing (SSTOL)

The key to operating at small airfields is the ability to maintain controlled flight at low airspeeds. Such capability allows a reduced ground speed at touchdown and a reduced stopping distance. To accomplish this slow speed flight, the aircraft must either have the capacity to generate tremendous lift, or reduce the requirement for lift at the

lower speeds. One way to increase lift is to apply airflow across the portions of a fixed wing that would otherwise stall. This allows the aircraft to fly at higher angles of attack, and is known as boundary layer control.<sup>156</sup> The other method for reduced speed flight is to transfer the thrust vector from a fore/aft direction to the vertical. This essentially puts it more in line with the lift vector, similar to that of a helicopter. This concept is known as tilting.

*Tilt Wing.* As opposed to the V-22 tilt rotor concept, in the tilt wing design the engines and propellers are fixed relative to the wing. In transitioning from normal to slow speed flight, the entire airfoil tilts, and rotates the thrust axis with it. In addition, because the engines are in the same position relative to the wing, the propeller airflow across the wing is still creating lift. This concept was first tested over thirty years ago, most notably in the XC-142 and XL-84 aircraft.<sup>157</sup>

**Figure 3. Boeing Tilt Wing Advanced Theater Transport**



Source: The Boeing Company

---

<sup>156</sup> USAF Test Pilot School, “Performance Flight Testing Phase, Subsonic Aerodynamics,” (Edwards AFB, Calif.: Air Force Flight Test Center, November 1992), 2.61.

<sup>157</sup> Ling-Temco-Vought Inc., *Applications of the C-142 V/STOL Transports* (Dallas, Tex., 1965). Also, David Mondey, ed., *International Encyclopedia of Aviation* (New York: Crown, 1977), 362.

The Boeing Company is using this design as the basis for its Advanced Theater Transport design (see Figure 3). The wing is designed to tilt up to forty-five degrees from its cruise configuration. The aircraft also employs high lift devices such as externally blown flaps, similar to those used on the C-17.<sup>158</sup> Initial analysis on this concept concluded that with the fly-by-wire flight control system and design of the body, the control effectiveness at slow speed offered by an elevator is marginal. For this reason and in the interest of weight savings, the present design calls for a tailless configuration.<sup>159</sup> Though the program still primarily consists of a “paper” airplane (no full-scale prototype), simulation and modeling analysis has determined that the proposed design configuration will meet the AAN requirement to deliver thirty tons into and out of a 750-foot runway.<sup>160</sup>

*Circulation Control Wing.* This concept is a subset of boundary layer control. In order to provide continued control at low speeds, the circulation control is basically designed to prevent the wing from stalling. This is done by “introducing a high-energy jet onto the upper, trailing edge region of a blunt trailing edged airfoil (occasionally leading-edge blowing is also used).”<sup>161</sup> This method to produce lift at low speed, combined with other advanced high lift devices and the lift efficiency of a blended wing-

---

<sup>158</sup> W.H. Deckert and J.A. Franklin. *Powered-Lift Aircraft Technology* (Washington, D.C.: Scientific and Technical Information Division, National Aeronautics and Space Administration, 1989), 5.

<sup>159</sup> Interview with Mr. Mike Rohrlick, ATT Program Manager, Boeing Co., 18 Feb 99.

<sup>160</sup> Briefing delivered by the ATT team on 18 Feb 99. The briefing slides are Boeing proprietary. Information released under the approval of Mr. Rohrlick at Boeing Co., Long Beach Ca.

<sup>161</sup> John W. Trainor, “A Wind Tunnel Study of a Sting-mounted Circulation Control Wing” (Wright-Patterson AFB, Ohio: Master’s thesis, Air Force Institute of Technology, December 1989) 2.

body design, is the cornerstone of the Lockheed ATT strategy for SSTOL (see Figure 4). As with the Boeing concept, the concept has not been funded to allow for a prototype. Current analysis shows that to operate with the thirty ton payload set by the Army, the aircraft can land in the required distance, but would require nearly 1,200 feet for takeoff. The 750-foot runway would allow payloads for takeoff of up to 20,000 pounds.<sup>162</sup>

**Figure 4. Lockheed Advanced Theater Transport**



Source: Lockheed Martin Aeronautical Systems Co., Georgia

### **Opportune Landing Sites**

To maximize theater airlift flexibility, it is important to be able to provide the battlespace commander several options to support operations. In the Army After Next environment, this will become even more important as theater airlift evolves from a delivery and sustainment force to a combat maneuver element. Currently, there are

---

<sup>162</sup> Limitations are based on takeoff performance. Briefing slides prepared by Lockheed Martin. Information released under the approval of Mr. John Nichols, Senior Specialist Engineer – Advanced Concepts Team, Lockheed, Ga.

several restrictions placed on runway operations based on surface hardness, smoothness, and distance. Even in a potential austere environment, members of a ground combat control team (CCT) must perform a significant evaluation of the surface environment before operations are permitted.<sup>163</sup> In the future seen by the AAN, such evaluations are not practical. The time and resources invested in investigating possible landing sites will detract from the primary missions. In addition, such operations are likely to increase the vulnerability of the airlift missions by potentially alerting the enemy of intended future use of a particular area. The opposing needs of providing flexibility in a fluid combat environment and ensuring safe airlift operations in the forward area present a challenging dilemma.

A study group made up primarily of members from Boeing and Bowling Green State University was recently established to solve this problem. The basic concept being developed involves the use of commercially available and relatively inexpensive satellite imagery, combining it with advanced modeling techniques and identifying locations suitable for landing within an area of interest.<sup>164</sup>

The process is far too complex to elucidate fully within the framework of this thesis. Many of the details are still proprietary, but a brief synopsis is possible. Analysts obtain thirty-meter resolution satellite imagery of the area of interest. They then exclude known unusable geographic features such as mountain peaks and bodies of water. In addition, during the first “filtering” exercise, analysts identify pixels on the imagery containing large amounts of chlorophyll, indicating areas of lush vegetation or forests. This narrows

---

<sup>163</sup> Briefing delivered to C-17 test team by CCT prior to semi-prepared runway testing, August 1996.

the field of study, and allows the analysts to pick various landing candidate areas for further investigation. They then assess parameters such as brightness and “shading” to model the surface type. By applying known characteristics of surface types to surface conditions, the analysts can then predict suitable landing sites without the need for actual on-site inspection.<sup>165</sup>

Though the concept may appear far-fetched, the preliminary results to date have been quite impressive. During a field study in South Dakota in 1998, the test team sought to predict suitable landing surfaces, given requirements for minimal slope, no obstacles, no standing water, no thick vegetation, and weight bearing capacity. At the thirty-six sites analyzed, the test team predicted which were suitable and which were unsuitable with 100% accuracy.<sup>166</sup> Though this technology is in its infancy, it possesses the potential to provide the battlespace commander with flexibility in employment options and schemes of maneuver.

### **Precision Airdrop**

From the ground, the C-130 flying at 30,000 feet is a mere speck in the sky, and the payload kicked out the back is invisible in the early morning darkness. The transport airplane is well on its way home by the time the delivery drops into its target zone; the 20-minute descent is autonomous, silent, passive and purposeful.<sup>167</sup>

---

<sup>164</sup> Briefing delivered by Don Jennings, Principal Engineer, Advanced Transports and Tankers, Boeing Co., 18 Feb 99.

<sup>165</sup> Ibid.

<sup>166</sup> Ibid.

<sup>167</sup> Andrew Braunberg, “Parachute Guidance Empowers Programmed Payload Placement,” *Signal*, vol. 50 no. 9 (May 1996), 83.

Such a scenario is possible through the development of a precision airdrop capability. This would allow resupply in austere areas without subjecting the aircraft to enemy fire. If done in periods of reduced visibility it will also prevent alerting the enemy of the whereabouts of friendly forces. Current low level airdrop in the C-17 requires the crew to navigate to an area, program the known information about the cargo and parachute, and obtain current surface wind conditions from ground personnel on the drop zone. The crew then flies to the computed air release point (CARP) and releases the load. From there, the load becomes a free-fall, passive system with accuracy dependent on factors such as wind predictions, navigation accuracy, actual load exit time, and chute deployment time. Precision airdrop improves on this capability by adding GPS-aided guidance and control to the system, essentially steering the load to the target.

One basic design, known as the guided ram-air parafoil, consists of a large rectangular parachute (similar in shape to those used by demonstration teams) with a guidance and control package attached to the base of the risers.<sup>168</sup> After release from the aircraft and subsequent parachute deployment, the guidance would “fly” a programmed descent profile, adjusting for current conditions. Recent test efforts have set a near-term goal of a 42,000 pound platform delivered from an altitude of approximately 25,000 feet at a horizontal distance of over ten miles, landing within thirty feet of its intended target.<sup>169</sup>

Another precision airdrop design under investigation is a deployable fabric wing vehicle. This system consists of a folded wing package with guidance and control sitting

---

<sup>168</sup> A.W. Bennett and C. L. Wood, “Precision Airdrop System Development” (Wright-Patterson AFB, Ohio: Air Force Material Command, March 1996), 4-36.

<sup>169</sup> *Ibid.*, 4-37.

atop the standard load. Upon release, an extraction chute deploys and unfolds the wing, allowing for guided gliding flight to the target. This system is not as robust as the guided parafoil, only capable of delivering 2,200 pounds of cargo with an accuracy of 100 feet. It does increase standoff capability, with the increased glide ratio of the wings allowing cargo deployment over thirty miles from the target.<sup>170</sup>

## **Cargo Handling Capability**

Two areas of emphasis emerge when designing cargo-handling capabilities of a future theater airlift platform: speed and autonomy. In projected Army After Next operations, the combat troops receiving the cargo will be highly mobile, and it is unlikely they will travel with any cargo handling equipment except for the strength of their own backs. Each of the following concepts is being developed with speed and autonomy in mind.

One design, known as the Robotic Transport System (RTS), consists of a crane-type mechanism designed to pick up loads and move them forward or aft to the appropriate position. Two rails on fuselage ceiling run the length of the cargo compartment to secure this mechanism. Robotic arms hang from these points and are manipulated to secure the cargo at its base. (See Figure 5) For cargo offload, the RTS then lifts the cargo off the floor, transfers it aft until the cargo clears the aft portion of the floor and deposits it in the bed of a waiting vehicle or on the ground.<sup>171</sup> For this crane-type operation to work, there must be enough upper fuselage “overhang” to allow vehicles to maneuver into offload

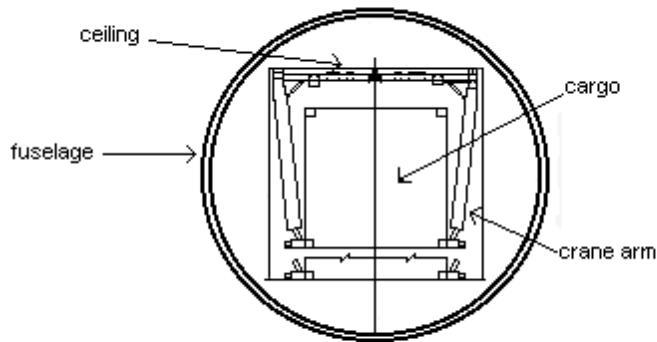
---

<sup>170</sup> Ibid., 4-41.

<sup>171</sup> James Gibson, “Technologies for Airlift Cargo Handling (TACH)” (WL-TR Wright-Patterson AFB, Ohio: Wright Laboratory, May 1993), 17.

position, or cargo to be lowered to the ground without interference from the aft portion of the fuselage floor. To facilitate this, the design that accompanies the RTS consists of a double hinged ramp. This ramp is connected to both the cargo floor and the ceiling by retractable hinges. This provides the capability to raise the ramp from the upper hinges and provide more overhang for the RTS rails to manipulate cargo.<sup>172</sup> (See Figure 6)

**Figure 5. Robotic Transport System (RTS)**

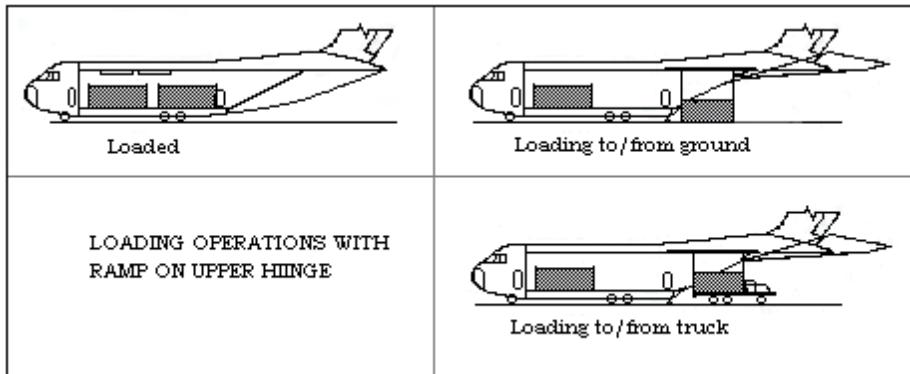


Source: James Gibson, “Technologies for Airlift Cargo Handling (TACH)” (WL-TR Wright-Patterson AFB, Ohio: Wright Laboratory, May 1993), 22.

---

<sup>172</sup> Ibid., 34.

**Figure 6. Loading with Double-Hinged Cargo Ramp**



Source: James Gibson, "Technologies for Airlift Cargo Handling (TACH)" (WL-TR Wright-Patterson AFB, Ohio: Wright Laboratory, May 1993), 25.

Another approach to improving cargo loading involves the use of an automated manipulator arm. This arm hangs from a turntable mechanism that is secured to the top of the fuselage in a manner similar to the RTS.<sup>173</sup> (See Figure 7) The function of the arm is to be a central yet mobile attachment point for various tools being used for onload/offload operations. The tools, such as trailer and flatrack dollies provide the hydraulic lifting and pulling power, and the mechanical arm provides the guidance and stability. In this same cargo compartment concept, the cargo ramp is double hinged, but in a different manner than the RTS. One hinge connects the ramp to the floor and a second hinge is in the middle of the ramp, allowing it to adjust to different vehicle heights.<sup>174</sup> Once the cargo is loaded, the system uses a combination of retractable rollers and belts to position the cargo.

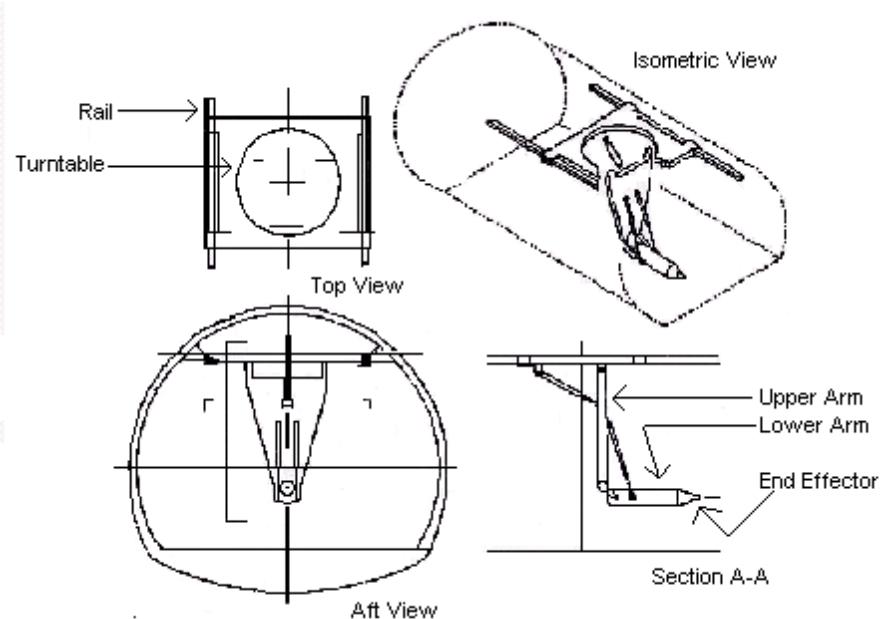
Advances in cargo floor design will greatly help cargo restraint operations. Currently, the loadmaster must manipulate a myriad of chains and straps to ensure

---

<sup>173</sup> M. A. Rohrlick, B. K. Rawdon, "Advanced Cargo Restraint System (ACRS) Project" (Wright-Patterson AFB, Ohio: Wright Laboratory, July 1994), 4-1.

adequate fore/aft restraint. Even in the C-17, with the most advanced cargo compartment in the inventory, the various restraint devices are encumbering, contributing to an increased aircraft reconfiguration time.<sup>175</sup> One design worthy of investigation includes a floor with multiple retractable tiedown devices. These devices are equipped with nearly all of the apparatus required to secure cargo, including a strap and hook. Embedding such devices throughout the cargo floor will greatly enhance loading efficiency, especially for cargo of nonstandard size and weight.

**Figure 7. Automated Manipulator Arm**



Source: M. A. Rohrlick, B. K. Rawdon, "Advanced Cargo Restraint System (ACRS) Project" (Wright-Patterson AFB, Ohio: Wright Laboratory, July 1994), 4-1.

<sup>174</sup> Ibid., 4-13.

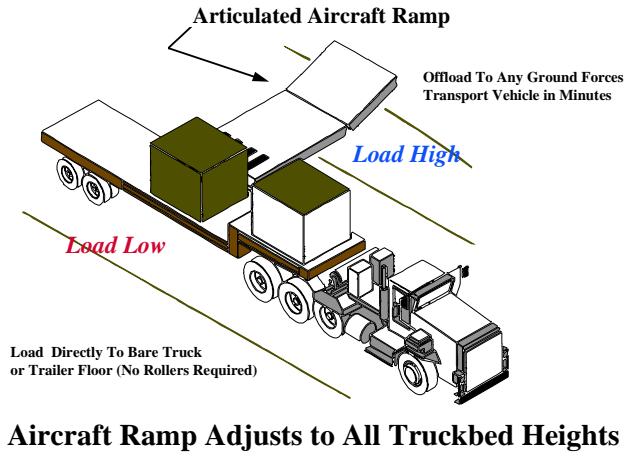
<sup>175</sup> Miguel Lopez and Michael Dodson, "Evaluation of C-17A Cargo Loading and Transport, Ground and In-flight Reconfiguration and Troop Transport Capabilities" AFFTC-TR-93-34 (Edwards AFB, Calif: Air Force Flight Test Center, March 1994), 16.

The newest and most comprehensive concept is known as the Load-by-Wire (LBW) system, currently being developed by Boeing. This system combines and updates many of the features of other designs.<sup>176</sup> An articulated ramp (see Figure 8) permits transfer of cargo from vehicles of varying heights, increasing loading efficiency. The LBW contains a container crane system designed primarily to load or unload the larger non-rolling stock from trucks. Two of the primary pieces of cargo in this category are the 8 x 20-foot International Standards Organization (ISO) container, and the palletized loading system (PLS) flatrack of the same dimensions. Once these cargo types are loaded, prepositioned retractable locks positioned for the ISO and PLS dimensions are engaged, and the cargo is instantly secured. For palletized cargo, tines extend to lift the cargo off the truck (the pallets will sit on shoring to allow room for tines to fit between the pallet bottom and truck bed) and power rollers reel the cargo onto the ramp. From there a pneumatically operated system of rollers, belts and chains will manipulate the cargo to the appropriate, where the retractable restraint devices will secure it in place. The crane system will also be used to lift any palletized cargo off the ground, or any other surfaces that do not provide space for the ramp tines to operate.

---

<sup>176</sup> Briefing and paper by Mr. Mike Rohrlick, ATT Program Manager, Boeing Co., on 18 Feb 99. Released under the authority of Mr. Rohrlick at Boeing Co., Long Beach, Ca.

**Figure 8. Load-By-Wire Articulated Ramp**



Source: Mr. Mike Rohrlick, "The Load-By-Wire System," The Boeing Company.

## Situational Awareness

As previously mentioned, AMC appears to be posturing adequately in this area for future airlift operations. Integration of GPS into all navigation systems greatly increases accuracy. Display technology has enabled such systems as digital moving maps and Head Up Displays to provide accurate information to the aircrew in a timely and effective manner. This is a good foundation for situational awareness. The next step is to enhance the ability to react in a dynamic environment. This is the idea behind the concept of real time information in the cockpit (RTIC).

Currently, AMC is moving toward fielding an RTIC capability. Operational testing is underway on the design of the Airborne Battlefield Intelligence (ABI) system.

In layman terms, ABI will display signals the satellites, the RC-135 and AWACS are picking up and broadcasting such as the location of surface-to-air missiles, radar locations, airborne aircraft and other dangers....If a threat such as a surface-to-air missile

becomes active, a crew will be able to change their flight path as needed for safe mission operation.<sup>177</sup>

The ABI adds a second piece to the situational awareness puzzle. In addition to the increased positional awareness provided by navigational accuracy, the aircrew will have more information about enemy positions.

The next step in improving situational awareness is being addressed through the concept of automated data fusion. In this instance, fusion is defined as “the evaluation of data from one or more sources to extract knowledge about events or objects of interest.”<sup>178</sup> Such a concept goes beyond the realm of information gathering and display, and attempts to interpret the data to predict intentions. This is indeed a daunting task, and the Scientific Advisory Board recommending its pursuit recognizes the difficulties due to “its immense computational requirements, and because robust interpretations of sensor data are hard to develop from mathematical considerations alone.”<sup>179</sup> On the positive side, situational awareness is not an all or nothing proposition, and even incremental changes will help the aircrew of the future to accomplish the increasingly demanding mission.

---

<sup>177</sup> Capt Linda P. Meyer, “Increasing Situational Awareness in Air Mobility Command Aircraft,” *Airlift/Tanker Quarterly*, vol. 6 no. 1 (Winter 1998): 19.

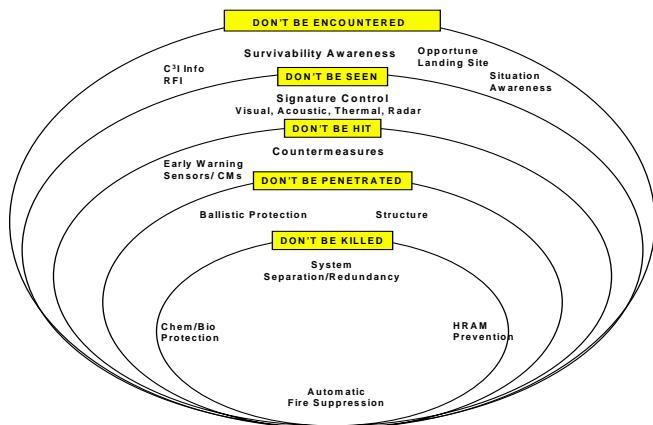
<sup>178</sup> Charles L. Morefield, *New World Vistas, Air and Space Power for the 21<sup>st</sup> Century, Information Applications Volume* (Washington, D.C.: USAF Scientific Advisory Board, 1995), 1.

<sup>179</sup> *Ibid.*, 5.

## Defensive Systems

Figure 9 illustrates the concept of layered survivability.<sup>180</sup> Success on the outer layers diminishes the requirement for expending effort on the inner layer capabilities. This simplified construct will provide the framework for describing new defensive systems concepts.

**Figure 9. Layered Survability**



Source: Mr. Paul Barr, Senior Engineer/Scientist, ATT Program, Boeing, Company

*Don't be encountered.* This implies conducting operations in non-hostile territory. The AAN requirement for theater airlift is in conflict with this concept. The best approach to support this layer is through the use of situational awareness and opportune landing sites in an attempt to avoid any encounter with enemy forces.

*Don't be seen.* Perhaps the most effective method of accomplishing this goal is in the form of stealth. Lockheed has incorporated this heavily in their ATT concept. They

---

<sup>180</sup> This figure was adapted from a briefing on Aircraft Threat Protection, and is presented under the approval of Mr. Paul Barr, Senior Engineer/Scientist, Boeing, Co., Long Beach, Ca.

propose that much of the stealth technology development costs have been paid, and for the incorporation of low observable capabilities on the ATT, "F-22 levels of signature reduction will work."<sup>181</sup> Another approach to this objective is through passive navigation. This involves the use of digital moving map in place of traditional emitting navigation aids.<sup>182</sup>

*Don't be hit/don't be penetrated.* These objectives have gained emphasis in recent years, sparked by such events as the Italian Air Force transport shot down approaching Sarajevo in 1993.<sup>183</sup> Air Mobility Command has identified the increasing surface-to-air threat, and is scheduled to have all C-17 and C-130 aircraft equipped with current defensive systems by FY2006.<sup>184</sup>

One deficiency in current defensive systems is the lack of infrared missile detection capability. The Scientific Advisory Board has acknowledged this shortfall, and claims that the technology is just around the corner.<sup>185</sup> Though insufficient in and of itself, identification is a necessary step to survivability because it allows more efficient use of the onboard defensive systems. Defensive countermeasures also have room for growth.

---

<sup>181</sup> Briefing slides by Lockheed on ATT concept received 4 Mar 99. This briefing was proprietary and the quote is cited under authorization of Mr. John Nichols, Senior Specialist Engineer – Advanced Concepts Team, Lockheed, Ga.

<sup>182</sup> Lt Col John A. Skorupa, *Self Protection Measures to Enhance Airlift Operations in Hostile Environment* (Maxwell AFB, Al.: Air University Press, September 1989), 100.

<sup>183</sup> Nick Cook, "Shielding the Airlifters," *Interavia*, vol. 52 no. 613 (October 1997), 41.

<sup>184</sup> US Air Force Air Mobility Command, "Combat Operations" 1998 *Air Mobility Master Plan Update*, , n.d., n.p.; on-line, Internet, 10 March 1999, available from [http://public.scott.af.mil/hqamc/about/ammp/EQUIPMNT/A\\_operln/3\\_COMBAT.htm](http://public.scott.af.mil/hqamc/about/ammp/EQUIPMNT/A_operln/3_COMBAT.htm).

<sup>185</sup> Scientific Advisory Board, *New World Vistas, Air and Space Power for the 21<sup>st</sup> Century, Mobility Volume* (Washington, D.C.: USAF Scientific Advisory Board, 1995), 18.

Though it is not trivial, solving the problem of detecting missile launch and trajectory provides the opportunity to defeat the missile by destruction, rather than spoofing, jamming, or evading. One such countermeasure is a directed energy weapon. This involves the use of an onboard laser or high-power directed microwave system to defeat the missiles. This offensive capability offsets the lack of maneuverability, and takes advantage of the fact that “ transports have much more space and power available than tactical aircraft and hence [a directed energy system] is more feasible.”<sup>186</sup>

*Don't be killed.* This is an objective that aircrew obviously will not want to depend on, but will be grateful it was considered if the time comes. Primary areas for consideration when designing a new theater airlifter will include durable composite structures and separation and redundancy of critical systems. One example of a unique approach to redundancy is a study conducted by NASA known as the propulsion controlled aircraft (PCA). The concept involves programming the flight controls to interface with the electronically controlled engines to provide aircraft control in the event of loss of hydraulic power to the flight controls.<sup>187</sup>

## **It All Sounds Good**

The list and description of future concepts in this chapter is by no means complete. It is however, an attempt to identify feasible paths to bridge the gap between the theater airlift system as it is and the system as it should be to support the Army After Next. Future concepts are exciting and spark interest in all that is possible. It is important for

---

<sup>186</sup> Ibid., 19.

<sup>187</sup> I participated in the study and flew as a guest test pilot to evaluate the system on the MD-11 on 30 November 1995.

planners to focus on the application of those concepts and not be lured by the soothing sounds of the technological Sirens. Within the four criteria for evaluation, some concepts were in opposition to others, while some were complementary to any future system. This chapter's intent has been to show what is *possible*; it is the intent of the following chapter to establish what is *best*.

## Chapter 6

### Analysis and Conclusions

*The color of the cat doesn't matter as long as it catches the mice.*

—Chinese Proverb

The Advanced Theater Transport should be a supersonic aircraft capable of all-spectrum stealth, even as it slows to a hover and feathery-soft touchdown, shortly after which it nearly instantaneously onloads the awaiting mechanized battalion for transit and offload 100 kilometers away.

Fiction aside, when charting a course for the future of theater airlift, it is important to focus on the ultimate aim. The goal is not merely to develop a system that outperforms any other in accomplishing the current mission, but rather one that can best accomplish the missions forecast throughout its service life. The Army After Next is pursuing a concept of operations that makes even our newest theater airlift assets inadequate.

Before delving into the analysis, there is a point that bears repeating. An entering assumption to this thesis was that the future operational concept of the Army After Next *or something that strongly resembles it* will become a reality. This is not a blind leap of faith. The Air Mobility Master Plan, the Air Force 2025 study, Marine Corps “Operational Maneuver From The Sea (OMFTS)” and *Joint Vision 2010* are pursuing and planning for substantial technological advances, and current trends are encouraging. In keeping with the themes of this paper, the following analysis will first be structured

around the four evaluation criteria. Because a system is more than just the sum of its parts, the overall evaluation will include significant factors beyond AAN supportability.

## Austere Operations

Based on collected and presented in the previous chapter, the Boeing tilt wing aircraft provides the greatest capability for austere operations. The powerful propellers, wing tilt, and body design enable the super short takeoff and landing capability to meet the Army thirty ton/750-foot runway requirement described in TRADOC Pamphlet 525-66.<sup>188</sup> The Lockheed ATT design data shows the ability to land with a payload of thirty tons within the required distance, but takeoff distance requires another 400 feet.<sup>189</sup> The Lockheed design would be adequate for the SSTOL capability if the future theater airlift force mission continues to be delivery and sustainment, as it is today. The AAN concept, however, calls for theater airlift to become a maneuver element. This would require the ability to *deliver* and *retrieve* ground personnel and equipment. Only the Boeing tilt wing provides the capability to takeoff with thirty tons in the required distance.

The precision airdrop approach is another option that greatly enhances the current airlift mission. Precision standoff delivery is an excellent way to increase aircrew survivability and place equipment very close to where it is needed. This technique does present new issues. The expense of the guidance and control unit on the parafoil

---

<sup>188</sup> TRADOC, Pamphlet 525-66, *Future Operational Capability TC 97-004. Super Short Takeoff and Landing (SSTOL)*, n.d., n.p.; on-line, Internet, 6 March 1999, available from <http://www-tradoc.army.mil/tpubs/pams/p525-66e.htm>. Boeing ATT information released under the approval of Mr. Rohrlick, ATT Program Manager, Boeing Co., Long Beach Ca.

<sup>189</sup> Lockheed ATT information released under the approval of Mr. John Nichols, Senior Specialist Engineer – Advanced Concepts Team, Lockheed, Ga.

(estimated at approximately \$50,000)<sup>190</sup> dictates that it not be left behind. The unfolded wings on the glided system must also have the capability to be easily re-folded if it is to be transported with the ground personnel. Both of these systems become dead weight, traveling with a force attempting to be as light and mobile as possible. Even if these problems are no more than an annoyance, the precision airdrop systems do not present satisfactory austere operations capability in themselves. They also only fulfill the delivery requirement of future theater airlift.

At least as important as the platform for supporting the AAN is the system that enables that platform to operate in its intended fashion. The opportune landing site (OLS) concept, or similar technology is *critical* to the complete fulfillment of the AAN support requirements. An operative OLS system directly supports both flexibility and survivability. Determination of suitable landing areas throughout the battlespace provides the commander with multiple options for orchestrating the “ambush dynamic” the AAN seeks.<sup>191</sup> Eliminating the need for extensive ground site surveys enhances the principles of surprise and security.

## **Cargo Handling Capability**

Austere and hastily prepared landing sites in the future will not have the right amounts and types of traditional materials handling equipment needed to unload the

---

<sup>190</sup> Andrew Braunberg, “Parachute Guidance Empowers Programmed Payload Placement,” *Signal*, vol. 50 no. 9 (May 1996), 83.

<sup>191</sup> U.S. Army Training and Doctrine Command (TRADOC), *Knowledge and Speed: Battle Force and the U.S. Army of 2025, The 1998 Annual Report on the Army After Next Project to the Chief of Staff of the Army*, (Fort Monroe, VA: TRADOC, 1998), 27.

ATT, and unloading operations in exposed forward sites must be accomplished quickly in order to reduce risks to the ATT, its crew, and the ground unit receiving the cargo.<sup>192</sup>

Each system described presents a vast improvement over current capabilities to handle cargo in an austere environment. The advantages presented by an autonomous, self-contained system are glaring; they give cause to question why such systems have not been integrated into current aircraft. In point of fact, there were earlier cargo aircraft designed with limited enhanced cargo handling capability. The Douglas C-74, and its more widely produced follow-on, the C-124, both had an internal elevator system to accommodate the split-level cargo compartment. Each also had a built-in crane to aid in cargo loading.<sup>193</sup> These aircraft were designed in 1942 and 1949. The cargo aircraft of today were designed later in the cold war. During that time, forward basing provided aerial ports from which external materials handling equipment (MHE) could be used for cargo operations. This alleviated the need for robust onboard systems, saving development costs and aircraft weight. Since that time forward basing has dried up, and MHE has become an Achilles Heel.

An airlift system is only as capable as the materials handling equipment (MHE) supporting it. Our current MHE fleet's inventory, age, and reliability hinder our ability to fully support 2 MRCs.<sup>194</sup>

---

<sup>192</sup> Jeffrey Record, *Determining Future U.S. Tactical Airlift Requirements* (Washington: Pergamon-Brassey's International Defense Publishers, 1987), 36.

<sup>193</sup> Rene J. Francillion, *McDonnell Douglas Aircraft Since 1920* (London: Putnam & Company, 1979), 407, 467.

<sup>194</sup> United States Air Force Air Mobility Command, *AMMP: Air Mobility Master Plan* (Scott AFB, IL, 1997), 1-31.

The Load-By-Wire (LBW) system provides the most robust cargo handling capability. By combining the best features of other designs, the LBW promises the ability to autonomously onload/offload nearly any cargo. The articulated ramp adapts to various truck heights for faster load transfer. When combined with a wide body design, the LBW will be capable of laterally transferring cargo, if necessary. This could be very useful, depending on the type and quantity of cargo onboard. For example, in its role of sustaining the smaller, demassed forces, it is conceivable that one ATT may have cargo A, B, and C for destinations X, Y, and Z, respectively. Proper load planning would ensure if destination X was to be reached first, cargo A would be positioned closest to the ramp. Any diversion to destination Y on a narrow body ATT without an LBW-type system would involve a significant ground delay. Cargo A would have to be offloaded, then cargo B, followed by a reload of cargo A. Depending on the type and quantity of cargo, such a scenario on a wide body ATT with LBW would involve less delay. With the aid of automated lateral and fore/aft system of belts, chains, and rollers, the LBW could potentially move cargo along the floor similar to a “Chinese puzzle.” A wide body ATT also offers more rapid handling capability simply because of the increased surface area at the rear of the aircraft for cargo transfer.

The key to obtaining such a comprehensive cargo handling system is to integrate it fully into the aircraft design. The concept brings with it several challenges. Cost is always an issue in the development of any revolutionary system. In addition, planners must closely monitor the aircraft weight increase caused by such a system, and evaluate that against required performance. The use of lightweight composite structures may significantly alleviate the weight problem. The increased potential for operations in

hostile environments dictates that survivability and redundancy issues are addressed with any critical system. With its essential role in supporting the AAN, The Load-By-Wire cargo handling system certainly qualifies as such a system.

## **Situational Awareness**

This evaluation criterion did not produce significantly alternative paths to achieve the desired situational awareness capability for the 21st century theater airlifter. The collective thinking is that more is better. To this point, current systems such as GPS and Head Up Displays have been integrated into airlift platforms without regard for other users. This has not interfered with the enhancement of basic situational awareness: knowing where you are. Knowing where the enemy is involves interaction with other system users, and as such requires a highly adaptable architecture. The current rate of technological change suggests that new systems' potential capabilities might be artificially limited by the need for interoperability. An adaptive architecture will alleviate this setback by building "growing space" into the system.

The current ABI system will surely provide lessons for future real time information in the cockpit (RTIC) systems, and those must be rolled into the ATT concept. Because the ATT will be one of many users of a large system, the designers will not have to devote significant time and energy to developing an entire system. Instead they must focus on tailoring the ATT avionics and information suite to integrate with the overall network. The ATT team does not have to build the boat, but they need to be on it when it leaves the dock.

This paper has described (with guarded optimism) the extent to which the Army After Next will exploit information technologies to achieve battlespace awareness. By

integrating into the system, the ATT can enhance combatant commanders' flexibility by providing them real time information on the status of potential maneuver assets. In addition, such situational awareness capability supports the focused logistics piece of *Joint Vision 2010* providing

the fusion of information, logistics, and transportation technologies to provide rapid crisis response, to track and shift assets even while enroute, and to deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical level of operations.<sup>195</sup>

## **Defensive Systems**

Applying the concept of layered survivability, the use of low observable (LO) technology provides the most advantageous defensive capability by accomplishing the objective of "don't be seen." Based on this statement alone, the Lockheed ATT design has an advantage over the tilt wing aircraft. Operations in support of the AAN "move-strike-move battle rhythm"<sup>196</sup> will be conducted throughout a disputed battlespace. The ability to maneuver and sustain combat forces without being detected not only enhances survivability, but also the security of the supported ground forces. This being said, the unique mission of the future theater airlift force raises questions on the utility and feasibility of a LO design.

One of the primary missions of the ATT will be operating at austere airfields. This implies a semi- or unprepared surfaces with a potential for foreign object damage (FOD).

---

<sup>195</sup> Joint Chiefs of Staff, *Joint Vision 2010* (Washington, D.C.: Joint Chiefs of Staff, 1995), 16.

<sup>196</sup> TRADOC, *Knowledge and Speed* 1998, 27.

In conventional aircraft, FOD is most hazardous if the debris impacts flight control surfaces or is ingested into the engines. In stealth aircraft, FOD takes on a whole new meaning. The entire surface integrity is essential to retaining low observable capability.<sup>197</sup> Operations through these austere fields may significantly increase the radar cross section and make the aircraft more vulnerable.

To date, stealth has been an integral part of the design of three U.S. aircraft: the F-117, B-2, and now the F-22. Each of these was designed to operate in a high altitude environment, where radar cross section reduction is a significant enhancement. From its infancy, the ATT concept has been developed for a mission in which its ingress and egress are flown at altitudes as low as 200 feet.<sup>198</sup> In this environment, the ATT crew must also be concerned with small arms fire, AAA, and infrared (IR) and optically guided manportable air defense (MANPAD) missile systems. The stealth answer to such a problem is that if enemy forces can't see the aircraft on radar, they can't alert forces within its predicted flight path. Those forces would then be reduced to small arms fire or AAA they can bring to bear in an impromptu manner, greatly increasing the ATT chances for survival.

Such a strategy might be very effective for an aircraft constantly maneuvering through the battlespace. The ATT will not have this luxury, as its primary mission will be to pick up and deliver troops and equipment throughout the disputed area. During its

---

<sup>197</sup> Ben Rich and Leo Janos, *Skunk Works: A Personal Memoir of My Years at Lockheed* (Boston: Little, Brown, 1994), 69. Rich relates a story in which the protrusion of three screws of less than 1/8 inch above the low observable surface showed up on radar "like a barn door."

<sup>198</sup> R. V. Wible, "Technology and design Considerations for an Advanced Theater Transport" in North Atlantic Treaty Organization, *Progress in Military Airlift* (France: AGARD, 1990), 19-7.

approach and landing, it must reconfigure, which includes extending its high lift devices and landing gear. This will greatly increase the radar cross section; a factor not considered in designing current stealth assets. Regardless of this fact, the Lockheed LO design for its ATT offers a greater level of survivability than its tilt wing counterpart. The question is “Is it enough?”

The potential for LO degradation and the diversity of the potential threats at low altitude demands that the ATT have more than just a stealthy shell. Current countermeasures are a step in the right direction, but low altitude operations compress the time between identification, reaction and countermeasure deployment. The directed energy weapon concept offers the most encouraging solution to this problem. The ability to defeat the missile threat by destroying it is more comforting than relying on outsmarting it. The methodology of intercepting the missile through computing its trajectory suggests a follow-on capability of locating and targeting its source. This capability could enhance survivability through destruction and deterrence.

The directed energy weapon concept brings with it a certain amount of risk. More so than the previous concepts under analysis, the success of the design depends on projected technological advances. Specifically,

Next generation fast computing will be required to solve the difficult pointing and tracking problem for a directed energy defensive system to be successful.<sup>199</sup>

Because of this, this method of aircraft defense should be treated with the guarded optimism required when considering several of the AAN information dominance

---

<sup>199</sup> Scientific Advisory Board, *New World Vistas, Air and Space Power for the 21<sup>st</sup> Century, Mobility Volume* (Washington, D.C.: USAF Scientific Advisory Board, 1995), 18.

prospects. Its potential value demands that it not only be given consideration, but also genuinely pursued for any aircraft with a mission similar to that of the ATT. As with several other concepts, weight and development costs will be important considerations.

The Load-By-Wire type cargo handling system will indirectly provide aircraft defense. By efficiently managing the cargo operations at the austere locations, the LBW can significantly reduce ground time. This provides an increased measure of security to the aircrew, cargo and supported ground personnel.

## **Other Key Considerations**

In the interest of limiting variables to provide more depth of focus, this paper has defined value primarily in terms of capability. However, to neglect the element of cost completely would be irresponsible. Nearly all of the new airlift concepts evaluated in this paper have been demonstrated to some extent. The future costs will be realized in the expansion of these concepts into an actual operational system. At this point, it is unknown if the costs of developing and fielding a tailless, tilt wing, turboprop aircraft will be more expensive than to do the same for a stealthy, blended wing-body, highly lift-augmented, turbofan aircraft. Each aircraft company possesses its own unbridled enthusiasm and optimistic projections, but further independent research involving a developmental cost comparison would be invaluable.

One strategy that Lockheed is pursuing to reduce costs is to make the basic aircraft design capable of multiple roles, including a tanker and a special operations variant. This modular design concept would allow all aircraft variants to share a single production line for the bulk of the construction. The aircraft-specific modifications would include

fuselage and wing plugs designed to readily attach to the basic structure.<sup>200</sup> Additions such as low observable skin applique would only be included on the aircraft whose missions require it. This would provide cost savings by producing more of the basic aircraft and enabling economies of scale. Such modularity is also envisioned for the interior of the aircraft, allowing for reconfiguration to support different operations. Modularity has been identified by the *Air Force 2025* project as an important attribute of future systems.<sup>201</sup>

In pursuit of swing role capability, Boeing is developing a “tail package” for its design to accommodate the air refueling. In this system, the aft portion of the articulated ramp can be removed and replaced by a similar plug equipped with an extendable aerial refueling receptacle. The new plug connects to the aircraft plumbing, and allows for refueling from the aircraft wing tanks. The same remote system used by the loadmaster for refueling will be adaptable for use by a boom operator, or an automated system. With the tilt-wing top speed of 400 knots (true airspeed), it is speed-compatible with all of today’s refuelable assets.<sup>202</sup>

Interoperability is also of interest when designing a new airlift capability. Supporting the operational forces in times of conflict is essential, but the aircraft possesses little overall utility if it is unable to integrate with the rest of the transportation

---

<sup>200</sup> Briefing slides by Lockheed on ATT concept received 4 Mar 99. The information is presented under the authorization of Mr. John Nichols, Senior Specialist Engineer – Advanced Concepts Team, Lockheed, Ga.

<sup>201</sup> US Air Force, “Airlift 2025, The First with the Most,” *Air Force 2025 Final Report*, August 1996, n.p.; on-line, Internet, 14 March 1999, available from <http://www.au.af.mil/au/2025.htm>.

<sup>202</sup> Interview with Mr. Mike Rohrlick, ATT Program Manager, Boeing, Co., Long Beach, Ca. Information released under the authority of Mr. Rohrlick.

system while carrying out its peacetime mission. Integration into the system includes the ability to accept and deliver cargo from other transportation modes expeditiously. The Army has recognized the need for such an intermodal capability in its requirements documents,<sup>203</sup> and the *Air Force 2025* project determined

Intermodality is a basic requirement for basic airlift systems. Cargo must be configured for direct transfer between air, land, sea, and space lift systems and operational use at delivery destination. Because we anticipate the requirement to transfer military cargo on commercial carriers of all mediums when possible, military payload configuration must comply with national and international standards. Through cooperative international development, these configurations also allow direct synergistic support among operational allied, coalition, and U.S. forces.<sup>204</sup>

A Load-By-Wire type cargo handling system will greatly enhance intermodal operations. The International Standards Organization (ISO) twenty-foot container is becoming a more popular transport tool because it not only transfers readily to large truck beds, but also is conducive to stacking, which saves precious volume aboard ships. An aircraft cargo handling system with autonomous loading capability and prepositioned restraint devices on the cargo floor will increase efficiency and maximize throughput at transfer locations.

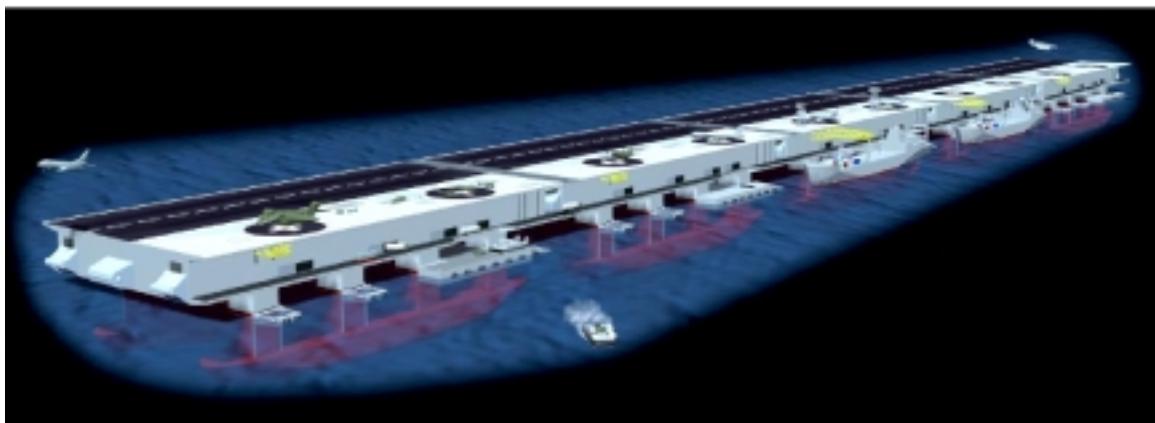
---

<sup>203</sup> TRADOC, *Pamphlet 525-66, Future Operational Capability*, TR 97-033, "Sustainment Transportation," n.d., n.p.; on-line, Internet, 6 March 1999, available from <http://www-tradoc.army.mil/tpubs/pams/p525-66e.htm>.

<sup>204</sup> US Air Force, "Airlift 2025, The First with the Most," *Air Force 2025 Final Report*, August 1996, n.p.; on-line, Internet, 14 March 1999, available from <http://www.au.af.mil/au/2025.htm>.

Enhanced cargo handling system and SSTOL capabilities also integrate well with emerging naval concepts for offshore bases. This idea may become increasingly necessary as diplomatic clearances and access to foreign soil for military operations becomes more difficult. One such concept consists of a set of hinged, semi-submersible modules designed to accommodate both ships and aircraft. (see Figure 10) The length of the offshore base can be adjusted to support the size and type of aircraft design to operate through it. With each 1000-foot module currently estimated to cost approximately \$1 billion, the advantage of SSTOL capability becomes readily apparent.<sup>205</sup>

**Figure 10. Mobil e Offshore Base**



Source: McDermott, Inc.

## Conclusions

For nearly a decade, victory in the cold war has allowed the United States to operate in the international environment as the sole superpower. This “strategic pause,” to use the popular vernacular, presents a unique opportunity to “prepare now for an uncertain

---

<sup>205</sup> Briefing by Admiral LaPlante (ret) from the McDermott Co., to the Air Mobility Symposium, Robins AFB, Ga, 29 Jan 99.

future” in support of the national security strategy.<sup>206</sup> The U.S. Army has taken this opportunity to develop a new force structure and doctrinal concept to respond rapidly and decisively throughout the spectrum of conflict. The Army After Next vision is far-reaching in its implications. Many of its critical enablers such as information dominance, ultrareliability, and total logistical situational awareness<sup>207</sup> are unproven concepts. Despite this, the AAN is an evolving concept, and even if the high-end goals are not attained, the spirit of the vision will be in future doctrine. This includes more reliance on information, dispersed forces and increased dependence on maneuver.

As the Army system evolves, the theater airlift system supporting it must also change. New logistical challenges will emerge, placing increased importance on the principles of flexibility and survivability. Added to this, future theater airlift will become an element of combat maneuver more than ever before. This paper posits that increased emphasis will be required in developing four particular capabilities of a future theater airlift system: 1) austere operations, 2) cargo handling capability, 3) situational awareness, and 4) defensive systems. From analysis of current capabilities shortfalls and alternative paths to meet the AAN requirements, this thesis draws several conclusions. The following is a brief summary of those conclusions and areas for suggested further research.

Given the design information from the various systems under development, the tilt-wing aircraft best meets the AAN SSTOL needs. Its airfield performance provides the ability to deliver *and* pick up the tonnage of cargo required, better enabling it to function

---

<sup>206</sup> White House, *National Security Strategy for a New Century* (Washington, D.C.: Government Printing Office, 1998), 23.

<sup>207</sup> TRADOC, *Knowledge and Speed 1998*, 33, 28, 36.

as a maneuver element. Further research involving a cost comparison between the tilt-wing and stealth ATT design would add value to this analysis.

The opportune landing site (OLS) concept is critical to realizing the level of maneuverability the AAN desires. The necessity of diverting ground forces to conduct site surveys significantly inhibits the combatant commander's ability to effectively orchestrate a move-strike-move campaign. Further development of this technology might also provide the commander better information to analyze terrain more effectively when planning horizontal maneuver.

Given the operating environment for future theater airlift, an automated Load-By-Wire (LBW) type cargo handling system offers essential capabilities. Its versatility and autonomy provide rapid cargo loading operations that enhance survivability of the aircrew, cargo, and supported ground forces. In addition, the ability to handle nearly any standard load type minimizes the need for external materials handling equipment (MHE). This provides cost savings as well as increased lift capacity as it frees up cargo space otherwise required for moving the external MHE. When coupled with a wide body ATT, the LBW provides even more rapid cargo onload/offload capability. In addition, the ability to laterally transfer cargo in a "double wide" compartment increases handling flexibility.

Situational awareness initiatives currently underway are adequate. The most important to consider in developing further systems is integration with the overall "information dominance" network.

For defensive systems, several variables cloud the issue, making the conclusions less clear. Stealth is a proven technology, and as such it is very attractive. The projected

mission of an ATT is unique in that a significant portion of its mission is at low altitude, sometimes slow, and occasionally static on the ground. The resulting susceptibilities are not adequately addressed by stealth, although it is sure to help in the enroute cruise portion of the mission. An offensive capability such as a directed energy weapon would greatly enhance crew survivability. Since such a system is currently not operational, research into costs and feasibility of fielding such a weapon on an ATT would greatly aid decision-makers. Research to explore the maintainability of stealth on aircraft operating in austere environments would also be very valuable.

Regardless of which type of platform or system is chosen, it is absolutely critical that tomorrow's systems be built to support tomorrow's missions. For the advanced theater transport platform, this means developing a new paradigm and measures of merit for mission accomplishment. If this paper has provided sharper focus and general direction to that end in any way, then it has served its purpose.

## ***Bibliography***

### **Books**

AAF Evaluation Board. *An Evaluation of 14<sup>th</sup> Air Force Operations During 1944 with Due Consideration Given to the Logistical Problems Involved*. Army Air Forces Evaluation Board, 1945.

Bowen, Lee et al. *USAF Airborne Operations: World War II and Korean War*. (Washington D.D.: Government Printing Office, USAF Historical Division, 1962.

Craven, Wesley Frank, and James Lea Cate, eds. *The Army Air Forces in World War II*. Vol. 4, *The Pacific: Guadalcanal to Saipan, August 1942 to July 1944*. 1949. New imprint, Washington, D.C.: Office of Air Force History, 1983.

Deckert, W.H. and J.A. Franklin. *Powered-Lift Aircraft Technology*. Washington, D.C.: Scientific and Technical Information Division, National Aeronautics and Space Administration, 1989.

Douhet, Giulio. *Command of the Air*. New York: Coward-McCann, 1942. Reprint, Office of Air Force History, 1983.

Francillion, Rene J. *McDonnell Douglas Aircraft Since 1920*. London: Putnam & Company, 1979.

Gansler, Jacques. *Defense Conversion: Transforming the Arsenal of Democracy*. Cambridge Mass.: MIT Press, 1995.

Hough, B. K. *Basic Soils Engineering*. New York: Ronald Press Co., 1957.

Jackson, Paul, ed. *Jane's All the World's Aircraft 1997-1998*. Alexandria, VA.: Jane's Information Group, Inc, 1997.

Johnson, Stuart E. and Martin C. Libicki. *Dominant Battlespace Knowledge*. Washington, D.C.: Institute for National Strategic Studies, revised ed. April 1996.

Miller, Lt Col Charles E. *Airlift Doctrine*. Maxwell AFB, Ala.: Air University Press, March 1988.

Mason, Herbert A., Randy G. Bergeron, and James A. Renfrow. *Operation THURSDAY: Birth of the Air Commandos*. Washington, D.C.: Air Force History and Museums Program, 1994.

Mondey, David, ed. *The International Encyclopedia of Aviation*; assistant compiler, *Jane's All the World's Aircraft*. New York: Crown, 1977.

Mondey, David, ed. *The International Encyclopedia of Aviation*; assistant compiler, *Jane's All the World's Aircraft*. New York: Crescent, 1988.

Motsek, Col Gary J. "Logistic Support to the Army After Next Warfighters: A Time for Fundamental Change," in AY 97 *Compendium Army After Next Project*. Edited by Douglas V. Johnson, II. Carlisle, PA: Strategic Studies Institute, 1998.

Peers, William R. and Dean Brelis. *Behind the Burma Road, The Story of America's Most Successful Guerrilla Force*. Boston: Little, Brown, 1963.

Prouty, R.W. *Helicopter Aerodynamics*. Potomac, MD: Phillips Publishing, Inc, 1985.

Record, Jeffrey. *Determining Future U.S. Tactical Airlift Requirements*. Washington: Pergamon-Brassey's International Defense Publishers, 1987.

Rich, Ben R. and Leo Janos. *Skunk Works: A Personal Memoir of My Years at Lockheed*. Boston: Little, Brown, 1994.

Skorupa, Lt Col John A. *Self-Protection Measures to Enhance Airlift Operations in Hostile Environments*. Maxwell AFB, Al.: Air University Press, September 1989.

U.S. Bureau of the Census. *Statistical Abstract of the United States, 1980*, (101<sup>st</sup> edition) Washington, D.C.: Government Printing Office, 1980.

U.S. Bureau of the Census. *Statistical Abstract of the United States, 1998*, (118<sup>th</sup> edition) Washington, D.C., Government Printing Office, 1998.

## Periodicals

“Aerospace Source Book: Rotary-Wing Outlook/Specifications.” *Aviation Week & Space Technology*, 11 January 1999, 76-83.

Braunberg, Andrew C. “Parachute Guidance Empowers Programmed Payload Placement.” *Signal*, vol. 50 no. 9 (May 1996): 83-85.

Braybrook, Roy. “New Technology Transports and Tankers.” *Armada International*, May 1997, 34-48.

Cook, Nick. “Shielding the Airlifters.” *Interavia*, vol. 52 no. 613 (October 1997): 41-44.

Cook, Nick. “Airlift Picture Coming into Focus.” *Interavia*, vol. 53 no. 625 (Nov 1988): 48-51.

Dunlap, Charles J. “21<sup>st</sup> Century Land Warfare: Four Dangerous Myths.” *Parameters*, vol. 27 no. 3 (Autumn 1997): 27-37.

Evers, Stacey. “USAF Special Ops seeks stealthy VTOL.” *Jane's Defence Weekly*, vol. 27 no. 16 (23 April 1997): 26027.

Ferris, Stephen P. and David M. Keithly. “21<sup>st</sup>-Century Logistics: Joint Ties That Bind.” *Parameters*, vol. 27 no. 3 (Autumn 1997): 38-49.

Garret, Col Stephen F. “Synchronizing Battlefield Logistics.” *Military Review*, vol. LXXVII no. 2 (March-April 1997): 19-22.

Gregory, Bill. “Revolution in Army Logistics.” *Armed Forces Journal International*, vol. 36 no. 3 (October 1998): 18-20.

Haas, Capt Peter M. “Palletized Loading System: Not Just Another Truck.” *Army Logistician*, September-October 1996, 14-20.

Hall, David H. “Integrated Survivability Assessment: Measuring the Balance.” *Aircraft Survivability*, Spring 1998, 12-14.

Hershman, Mark Shane et al. “Tactical Versus Strategic Role of the C-17: An Analysis of Operation Joint Endeavor.” *Air Force Journal of Logistics*, vol. 22 no. 2 (Summer 1998): 30-31.

Hewish, Mark. “A Precision Job: Stand-off Delivery in Air Drop Increases Survivability.” *International Defense Review*, vol. 28 (October 1995): 71-73.

Hewish, Mark. “Surviving a SAM Attack.” *Jane's International Defense Review*, vol. 29 (June 1996): 61-66.

House, Col John M. “The Enemy After Next.” *Military Review*, vol. LXXVIII no. 2 (March-April 1998): 22-27.

Killebrew, Col Robert. "The Army After Next: TRADOC's Crystal Ball Eyes The Service's Shape Beyond Force XXI." *Armed Forces Journal International*, vol. 134 no. 3 (October 1996): 38-45.

Killebrew, Col Robert. "The Army After Next: Defining Future Landpower Challenges." *Army*, vol. 48 no. 2 (February 1998): 23-28.

Meyer, Capt Linda P. "Increasing Situational Awareness in Air Mobility Command Aircraft." *Airlift/Tanker Quarterly*, vol. 6 no. 1 (Winter 1998): 19.

Morrocco, John D. "Europe Struggles to Fill Airlift Capability Gap." *Aviation Week & Space Technology*, 11 May 1998, 68-70.

Nash, Trevor. "Military Transport Aircraft – Size, Shape and Suitability." *Military Technology*, vol. 15 no. 5 (May 1991): 12-14.

Sherman, Jason. "21<sup>st</sup> Century Tank." *Armed Forces Journal International*, vol. 134 no.3 (October 1996): 46-51.

Shine, Col Alexander P. "Theater Airlift 2010." *Airpower Journal*, Winter 1988, 4-19.

Wilson, Gen Johnnie E. "The New Millenium: Getting There from Here." *Army*, vol. 49 no. 2 (February 1999): 19-24.

## Reports

Bailey, SSgt Scott M. "60,000 Pound (60K) Linked and 110,000 Pound (110K) Sequential Platform Low Velocity Airdrop (LVAD): Follow-on Operational Test and Evaluation (FOT&E) of the C-17 Aircraft." Fort Dix, N.J.: Air Mobility Command, Air Mobility Warfare Center, 33d Flight Test Squadron, 1998.

Bennett, Andrew W. and James F. Gibson. "Technologies for Airlift Cargo Handling (TACH): Application Study." WL-TR Wright-Patterson AFB, Ohio: Wright Laboratory, November 1994.

Bennett, A.W. and C. L. Wood. "Precision Airdrop System Development." Wright-Patterson AFB, Ohio: Air Force Material Command, March 1996.

Bennett, Gerald et al. "Tactical Airlifter Survivability in a Non-radar Threat Environment." Wright-Patterson AFB, Ohio: Air Force Systems Command, Aeronautical Systems Division, January 1987.

Bouras, Peter and Maj Pamela A. Melroy. "C-17A Unpaved and Matted Runway Operations." Report no. AFFTC-TR-95-22. Edwards AFB, Calif.: Air Force Flight Test Center, October 1995.

Bray, Maj Johnny W. "Information Dominance, Can We Afford It?" Research paper. Maxwell AFB, Ala.: Air Command and Staff College, 1997.

Chisman, R.S. et al. "Future Theater Airlift Studies: Two- Versus Four-Engine STOL Transport." Wright Patterson AFB, Ohio: Aeronautical Systems Center, Air Force Material Command, March 1993.

Cleary, Rodney L. and Franklin L. Spear III. "C-17 Crew Armor Protection." Report no. T/WR 96-02. Fort Dix, N.J.: Air Mobility Command, Air Mobility Warfare Center, 33d Flight Test Squadron, 1997.

Gates, Capt Jeffrey E. "C-17 Defensive System (DS) 1553B Bus Interface: Combined Developmental/Operational Test and Evaluation (D/OT&E), Detailed Test Plan."

T/WR 98-02. Fort Dix, N.J.: Air Mobility Command, Air Mobility Warfare Center, 33d Flight Test Squadron, 1998.

Geyser, Capt Michael J. "Mobile Microwave Landing System (MMLS) for Austere Airfield Operations: Tactics Development and Evaluation." Fort Dix, N.J.: Air Mobility Command, Air Mobility Warfare Center, 33d Flight Test Squadron, 1999.

Gibson, James F. "Technologies for Airlift Cargo Handling (TACH)." WL-TR Wright-Patterson AFB, Ohio: Wright Laboratory, May 1993.

Iya, Sridhar K. Heinz Gassert, and George J. Burmeister. "Technologies for Airlift Cargo Handling (TACH)." WL-TR Wright-Patterson AFB, Ohio: Wright Laboratory, May 1993.

Jiavaris, M. "C-17A Globemaster III Compatibility with the Expeditionary Airfield System." Report no. NAWCADLKE-MISC-48J200-0018. Lakehurst, N.J.: Naval Air Warfare Center, Aircraft Division, SE and ALRE In-Service Engineering Division, 1995.

Kamosa, Michael J. and Michael J. Welch. "Evaluation of C-17 Combat Offload Capabilities." Report no. AFFTC-TR-94-24. Edwards AFB, Calif.: Air Force Flight Test Center, October 1995.

Ling-Temco-Vought Inc. *Applications of the C-142 V/STOL Transports*. Dallas, Tex., 1965.

Lopez, Miguel A. and Michael Dodson. "Evaluation of C-17A Cargo Loading and Transport, Ground and In-flight Reconfiguration and Troop Transport Capabilities." AFFTC-TR-93-34. Edwards AFB, Calif: Air Force Flight Test Center, March 1994.

McCarthy, J. M. and F. M. Rudolph. "Autonomous Landing Guidance." Wright-Patterson AFB, Ohio: Wright Laboratory, December 1992.

McGee, Lt Col (CAF) John E. "Augmentor Wing Powered Lift Technology: Affordable Alternatives to Enhance Tactical Airlift Capability." Report no. AU-AWC-86-143. Maxwell AFB, Ala.: Air War College, 1986.

Martin, Eric J. and Scott M. Cone. "A Head-Up Display Symbology Evaluation for an Autonomous Landing Guidance System." WL-TR # 96-3104. Wright-Patterson AFB, Ohio: Air Force Material Command, May 1996.

Miles, W.L. et al. "Assault Transport Crew System Development." WL-TR Wright-Patterson AFB, Ohio: Air Force Material Command, July 1992.

Mohr, Dave et al. "Air Cargo Containerization Study." Gunter AFB, Ala.: Air Force Logistics Management Center, December 1991.

Rohrlick, Mike A. and Blaine Rawdon. "Advanced Cargo Restraint System (ACRS) Project." Wright-Patterson AFB, Ohio: Wright Laboratory, July 1994.

Sewell, A. "Advanced Theater Transport VSTOL and Super STOL Technology Integration and Assessment." Wright-Patterson AFB, Ohio: Wright Laboratory, 30 May 1991.

Society of Experimental Test Pilots. *Proceedings 1997: Forty-First Symposium Proceedings*. Lancaster, Calif.: Society of Experimental Test Pilots, 1997.

Society of Experimental Test Pilots. *Proceedings 1998: Forty-Second Symposium Proceedings*. Lancaster, Calif.: Society of Experimental Test Pilots, 1998.

Taylor, Joe G. *Air Supply in the Burma Campaigns*. Maxwell AFB, Ala: USAF Historical Division, Research Studies Institute, Air University, 1957.

United States Air Force. Air Mobility Command. *AMMP: Air Mobility Master Plan*. Scott AFB, IL, 1997.

United States Army Combined Arms Combat Developments Activity. "Advanced Medium STOL Transport (AMST) Study." Fort Leavenworth, Kan.: 1977.

United States Army Training and Doctrine Command (TRADOC). *Knowledge and Speed: Battle Force and the U.S. Army of 2025: The 1998 Annual Report on the Army After Next Project to the Chief of Staff of the Army*. Fort Monroe, VA.: TRADOC, 1998.

United States General Accounting Office. "Intratheater Airlift: Information on the Air Force's C-130 Aircraft: report to the Honorable John McCain, U. S. Senate." Washington, D.C.: USGAO, 1998.

United States Scientific Advisory Board. *New World Vistas: Air and Space Power for the 21<sup>st</sup> Century*. 16 vols. Washington, D.C.: USAF Scientific Advisory Board, 1995.

White House. *National Security Strategy for a New Century*. Washington, D.C.: Government Printing Office, 1998.

### **Unpublished Papers**

"Configuration Integration for Large Multi-purpose Aircraft." Wright-Patterson AFB, Ohio: Air Force Wright Aeronautical Laboratories, September 1985.

Davis, Maj Michael P. "Low Altitude Parachute Extraction System Approach to Extraction Zone Procedures." Scott AFB, Ill: Air Force, Air Mobility Command, June 1993.

Donoho, Capt James H. "An Analysis of Tactical Military Airlift." Wright-Patterson AFB, Ohio: Thesis (M.S.), Air Force Institute of Technology, 1997.

Haven, Maj Douglas L. "The Newest Seamless Airlifter: The C-130J-30." Wright-Patterson AFB, Ohio: Graduate research paper, Air Force Institute of Technology, 1998.

Helmeth, R.E. et al., "Analysis of Tactical Transportation: Progress and Challenges." Paper for Defense Systems Management College, 1988.

Hunter, Maj George F. "An Analysis of V/STOL Heavy Lift Logistics for the 1970's." Maxwell AFB, Ala., June 1968.

Johnson, Charles. "Acquisition of the C-17 Aircraft: A Historical Account." Maxwell AFB, Ala: Air University, 1986.

King, Capt Robert J. "An Analysis of the Future Requirements for Materials Handling Equipment in the Military Airlift Command." Wright-Patterson AFB, Ohio: Thesis (M.S.), Air Force Institute of Technology, 1987.

Koger, Capt John J. "An Analysis of Tactical Airlifter Characteristics and Their Impact on Theater Airlift System Performance." Wright-Patterson AFB, Ohio: Thesis (M.S.), Air Force Institute of Technology, March 1993.

LeCroy, Roy C. "Implications of Changing Combat Doctrine and Evolving Threats on Future Tactical Airlifter Requirements." Maxwell AFB, Ala: Air War College, 1985.

McHalek, Maj Edward D. "An Analysis of Tactical Airlift and Aerial Re-supply." Maxwell AFB, Ala: June 1967.

Nickles, Capt Keith E. "Global Reach and Air Cargo Operations: A Study in Materials Handling Equipment (MHE) Requirements." Wright-Patterson AFB, Ohio: Graduate research paper, Air Force Institute of Technology, 1996.

North Atlantic Treaty Organization. "Progress in Military Airlift" Flight Mechanics Panel Symposium. France: AGARD, 1990.

Riley, John Denny. "Airborne Invasion of Burma; Spring, 1944." Thesis (M.S.), University of Oklahoma, 1965.

Silver, 1Lt Michael Alan. "Theater Airlifter Survivability on the Ground." Wright-Patterson AFB, Ohio: Master's thesis, Air Force Institute of Technology, March 1993.

Trainor, Capt John W. "A Wind Tunnel Study of a Sting-mounted Circulation Control Wing." Wright-Patterson AFB, Ohio: Master's thesis, Air Force Institute of Technology, December 1989.

USAF Test Pilot School. "Performance Flight Testing Phase, Subsonic Aerodynamics." Edwards AFB, Calif.: Air Force Flight Test Center, November 1992.

"V/STOL Aircraft Characteristics Affecting Behavior of Supporting Surfaces." Vicksburg, Mississippi: Miscellaneous Paper/Water Experiment Station, July 1967.

## Manuals and Other Publications

Joint Pub 3-0. *Doctrine for Joint Operations*. 1 February 1995.

Joint Pub 4-0. *Doctrine for Logistic Support of Joint Operations*. 27 January 1995.

Joint Chiefs of Staff. *Joint Vision 2010*. Washington, D.C.: Joint Chiefs of Staff, 1995.

Multi-Command Regulation 55-130, Vol I, *Official Title*. 15 April 1993.

Multi-Command Regulation 55-130, Vol II, *Official Title*. 1 Aug 1993.

Robins Air Logistics Center. *T.O. 1C-130H-1, C-130H Operations Manual*. October 1998.

Robins Air Logistics Center. *T.O. 1C-130H-1-1, C-130H Performance Manual*. May 1986.

Wright-Patterson AFB, *TO 1C-17A-1-1, Performance Manual*. 15 August 95, Change 8, 1 September 98.

## Electronic Publications

Air Force Doctrine Document 2-6. *Air Mobility*, 24 February 1999. On-line. Internet, 14 March 1999. Available from <http://www.hqafdc.maxwell.af.mil/Library/Doctrine/afdd2-6.pdf>.

"Air Force Technology – V-22 Osprey –Medium Lift Multi-mission Tilt Rotor Aircraft," n.d., n.p. On-line. Internet, 11 March 1999. Available from <http://www.airforce-technology.com/projects/osprey/index.html>.

"Army Technology – CH-47D/MH-47E Chinook – Heavy Lift Helicopter." n.d., n.p. On-line. Internet, 11 March 1999. Available from <http://www.army-technology.com/projects/chinook/index.html>.

Chapman, Anne W. et al., "Prepare the Army for War: A Historical Overview of the Army Training and Doctrine Command, 1973-1998," Chapter 6, "Doctrinal

Renaissance," 1998, n.p. On-line. Internet, 23 February 1999. Available from <http://www.tradoc.army.mil/historian/pubs/TRADOC25/chap6.htm>.

“Characteristics of Force XXI Operations.” *Land Combat in the 21<sup>st</sup> Century*, n.d., n.p. On-line. Internet, 24 February 1999. Available from <http://www-tradoc.army.mil/text/landcmbt.htm>.

Director, Operational Test and Evaluation, Office of the Secretary of Defense. V-22 *Osprey FY97 Annual Report*, n.d., 2. On-line. Internet, 10 March 1999. Available from <http://dote.osd.mil/reports/FY97/navy/97mv22.html>.

“Engine Gallery – F117-PW-100,” n.d., n.p. On-line. Internet, 10 March 1999. Available from <http://pratt-whitney.com/engines/gallery/f117.html>.

Hanna, Mark. “Task Force XXI: The Army’s Digitization Experiment,” in *Strategic Forum, Institute for National Strategic Studies*. No. 119. July, 1997, n.p. On-line. Internet, 17 February 1999. Available from <http://www.ndu.edu/inss/strforum/forum119.html>.

Institute for National Strategic Studies “Adaptive Forces,” *1998 Strategic Assessment: Engaging Power for Peace*. n.d., n.p. On-line. Internet, 6 March 1999. Available from <http://www.ndu.edu/inss/sa98/sa98ch15.html>.

Joint Chiefs of Staff, J-4. *Information Fusion*, J-4 Projects. n.d., 2. On-line. Internet, 6 March 1999. Available from <http://www.dtic.mil/jcs/projects/foclog/info-fus.html>.

“Land Forces.” *Strategic Assessment 1996:Elements of U.S. Power*. n.d., n.p. On-line. Internet, 23 February 1999. Available from <http://www.ndu.edu/inss/sa96/sa96ch14.html#subhead2>.

Robertson, Gen Charles T. Jr. “Keynote Address to the Airlift/Tanker Association,” 24 October 1998, n.p. On-line. Internet, 6 March 1999. Available from [http://public.scott.af.mil/hqamc/speeches/ata\\_98.htm](http://public.scott.af.mil/hqamc/speeches/ata_98.htm).

Tilford, Earl H. Comments. *National Defense Into the 21<sup>st</sup> Century: Defining the Issues*, 6 June 1997, n.p. On-line. Internet, 22 February 1999. Available from <http://carlisle-www.army.mil/usassi/ssipubs/pubs97/natdefns/defnsp2.htm>.

US Air Force. “Airlift 2025, The First with the Most,” *Air Force 2025 Final Report*, August 1996, n.p. On-line. Internet, 14 March 1999. Available from <http://www.au.af.mil/au/2025.htm>.

US Air Force Air Mobility Command. “Combat Operations.” *1998 Air Mobility Master Plan Update*, n.d., n.p. On-line. Internet, 10 March 1999. Available from [http://public.scott.af.mil/hqamc/about/ammp/EQUIPMNT/8\\_AMCwep/4\\_C\\_130.htm](http://public.scott.af.mil/hqamc/about/ammp/EQUIPMNT/8_AMCwep/4_C_130.htm).

US Air Force Air Mobility Command. “Operations.” *1998 Air Mobility Master Plan Update*, n.d., n.p. On-line. Internet, 10 March 1999. Available from <http://public.scott.af.mil/hqamc/about/ammp/ROADMAPS/24.ds.htm>.

US Army Training and Doctrine Command. *Knowledge and Speed: The 1997 Annual Report on The Army After Next Project to the Chief of Staff of the Army*, July 1997, n.p. On-line. Internet, 23 February 1999. Available at “Papers” from <http://www.tradoc.army.mil/dcsdoc/fbdaan/aamframe.htm>.

US Army Training and Doctrine Command. Pamphlet 525-66, *Future Operational Capabilities*. n.d., n.p. On-line. Internet, 6 March 1999. Available from <http://www-tradoc.army.mil/tpubs/pams/p525-66e.htm>.